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SCIENCE ABSTRACTS.

SECTION A.—PHYSICS.

VOL. XVI
1913.

Issued by
THE INSTITUTION OF ELECTRICAL ENGINEERS,
VICTORIA EMBANKMENT, LONDON, W.C.;
Compiled and Edited by the Institution, in association with
THE PHYSICAL SOCIETY OF LONDON;
With the Co-operation of
THE AMERICAN PHYSICAL SOCIETY,
THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, and the
ASSOCIAZIONE ELETTROTECNICA ITALIANA.

LONDON:
E. & F. N. SPON, LIMITED, 57, HAYMARKET, S.W.
NEW YORK:
SPON & CHAMBERLAIN, 123, LIBERTY STREET.

ERRATA.

Section A.—PHYSICS.

- Abstract No. 76, line 4 : *for* Hönigschmidt, *read* Hönigschmid.
Abstract No. 78, line 19 : *for* Hönigschmidt, *read* Hönigschmid.
Abstract No. 153, line 7 : *for* Kirkcaldy, *read* Kirkaldy.
Abstract No. 266, line 3 : *for* Lune, *read* Laue.
Abstract No. 338, p. 114, line 4 : *for* Loschmidt, *read* Loschmidt.
Abstract No. 384, line 6 : *for* Lohmann, *read* Lehmann.
Abstract No. 466, line 3 : *for* R. H. Millikan, *read* R. A. Millikan.
Abstract No. 507, last line : *for* 1910, *read* 1911.
Abstract No. 547, line 11 : *for* Sommerfeld, *read* Sommerfeld.
Abstract No. 620, line 2 : *for* No. 14, *read* No. 15.
Abstract No. 1051, p. 341, line 12 : *for* Joulian, *read* Joulean.
Abstract No. 1065, line 3 : *for* Beckmann, *read* Beckman.
Abstract No. 1171, line 4 : *for* No. 133c, *read* No. 131c.
Abstract No. 1212 : *should read*, Abstract No. 1221.
Abstract No. 1293, line 4 : *for* 3×10^{-19} , *read* 3×10^{-9} .
Abstract No. 1483, last line : *for* Grossman, *read* Grossmann.
Abstract No. 1601, line 1 : *for* Limits, *read* Limbs.
Abstract No. 1648, line 2 : *for* Houston, *read* Houstoun.
Abstract No. 1837, line 6 : *for* Darwen, *read* Darwin.
Abstract No. 1880, line 1 : *for* Hopgood, *read* Hopwood.

AUTHORS' CORRIGENDUM.

- Abstract No. 1686 : *for* corrected numbering of plates, *see* Ann. d. Physik, 41. p. 1064.

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ALTERATIONS AND ADDITIONS IN LIST OF JOURNALS.

The List remains as in 1912. The following are Additions, and Alterations in Addresses, etc.

ABBREVIATION.	FULL TITLE	PRICE.	PUBLISHERS, OR AGENTS
Elect. Journ.....	The Electric Journal	8s. per annum, post free	Donington House, Norfolk Street, Strand, and 200, Ninth Street, Pittsburg, Pa., U.S.A.
Elektricitstvo.....	Elektricitstvo	12 roubles per annum ...	7 Roschdestwenskaja 4, St. Petersburg
Ferrum	Ferrum (late "Metall und Erz")	—	W. Knapp, Mühlweg, 19, Halle a. S., Germany
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Injener	Inžener, Kiev	—	—
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Kyushu Univ. Coll. of Engin., Mem.	Memoirs of the College of Engineering, Kyushu Imperial University, Fukuoka, Japan	—	Published by the University
Lick Observatory, Bull.	Lick Observatory, Bulletin	Price varies.....	Lick Observatory, University of California, Mount Hamilton, U.S.A.
Mount Weather Observatory, Bull.	Now combined with and called Monthly Weather Review	—	Chief U.S. Weather Bureau, U.S. Department of Agriculture, Washington, D.C.
N. Cimento	Il Nuovo Cimento	20 lire per annum, post free	A. Stefanini, Lung Arno Regio, 24, Pisa
Radio Engin. Inst., Proc.	Proceedings of the Institute of Radio Engineers, New York	Quarterly, separate copies, \$1	Published by the Institute, 81, New Street, New York City, U.S.A.
Russian Physico-Chemical Soc., Journ.	Journal Russkago Fiziko - Chimicheskago Obsčestva (Physical Part)	9 roubles per annum.....	Published by the Society, Imperial University, St. Petersburg

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- In Light* :—Absorption; Dispersion; Interference; Measurements and Use of Instruments; Miscellaneous; Phosphorescence and Fluorescence; Photography; Photometry; Polarisation; Radio-activity; Rays and Radiation; Reflection of Light; Refraction of Light; Spectra; Vision; Zeeman-Effect and Radiation in a Magnetic Field.
- In Heat* :—Absorption; Conductivity; Critical Points and Constants; Dilatation; Freezing, Melting, and Boiling-Points; Gases and Vapours; Measurements and Use of Instruments; Miscellaneous; Specific Heat and Latent Heat; Temperature; Temperatures (high and low); Thermodynamics; Thermometry, Pyrometry, and Calorimetry; Vapour Pressure.
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The Greesham Press
UNWIN BROTHERS, LIMITED
WOKING AND LONDON

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1913.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1913.

GENERAL PHYSICS.

1. *Sensitive Manometer.* A. Piccard. (Archives des Sciences, 84. pp. 258-260, Sept., 1912. Paper read before the Soc. Suisse de Physique; Altdorf, Sept., 1912.)—The apparatus is based on the principle of a U-tube containing at the middle a column of water. One end of the tube is bent downwards to dip into a vessel of water of large surface area, which can be moved in a vertical direction by means of a micrometer screw. The other end passes into a wider tube which has two outlet tubes, each provided with a tap; one of these outlets is at the top A of the wider tube, the other at the bottom B. The water meniscus in the narrow tube is observed with a microscope provided with a horizontal cross-wire. To ensure cleanliness of the tube walls, tap A is closed and a stream of hot sulphuric acid with potassium dichromate is passed in at B and right through the tube. Water, specially pure, is then gradually substituted for the cleaning mixture, until finally the apparatus is filled with pure water. Tap B is then closed, and A opened to the pressure to be measured, and the micrometer screw is turned until the meniscus is again in its original position. The difference of the micrometer readings then gives the required pressure. To keep the meniscus in excellent condition it is necessary only to allow air which has been filtered and saturated with moisture to enter the apparatus at A.

A. W.

2. *An Electric Micrometer.* B. Thieme. (Zeitschr. Instrumentenk. 82. pp. 822-825, Oct., 1912.)—A fine micrometer screw is mounted on a rigid frame, and by gearing can be rotated by small angles, and readings of $1/10000$ mm. obtained. Electrical, not mechanical, touch is employed, a galvanoscope being used as indicator. The error claimed for this arrangement in the measurement of a slab of nearly an inch is ± 0.00010 mm.

P. E. S.

3. *International Time Conference.* J. Reyval. (Lumière Électr. 20. pp. 177-180, Nov. 9, 1912.)—On the initiative of the Bureau des Longitudes
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B

a meeting was held at Paris on Oct. 15, 1912. A definite programme was agreed upon. Resolutions were passed arranging for each of a series of stations round the earth to receive time signals both by day and night, the number in general not to exceed four every 24 hours. From the 1st of Jan., 1913, the following stations will co-operate in issuing wireless time signals at the hours stated :—

Station.	Greenwich Mean Time.	Station.	Greenwich Mean Time.
Paris	0 h. midnight	Norddeich	19 h. midday
Brazil (San Fernando).....	9 a.m.	Brazil (San Fernando).....	16 p.m.
United States (Arlington)	8	United States (Arlington) ...	17
Mogadisco (Somaliland)	4	Massowah (Erythraea).....	18
Manila	4	San Francisco	20
Timbuctoo.....	6	Norddeich	22
Paris	10		

These hourly signals will be sent out with a uniform wave-length of 2500 m. The executive is to be an International Time Bureau, localised at Paris, and the various stations co-operating in the unification. It is hoped that all ships will be equipped with the necessary receiving apparatus, so that they may be able to correct their chronometers at any part of a voyage. Ice warnings are also to be distributed systematically. Certain groups of signals giving summaries of meteorological data are now being sent out regularly from the Eiffel Tower at Paris, and it is hoped to augment this service. A special committee was constituted to examine into the study of Hertzian-wave transmission and reception ; experiments are to be made at the high-power station at Brussels.

C. P. B.

4. *Motion of a Disc on a Rough Plane.* P. Field. (Phys. Rev. 85. pp. 177-184, Sept., 1912.)—A mathematical treatment of the motion on a rough plane of a disc with three supports. The motion is studied (a) when the disc, with three short legs, is initially given a large angular velocity about an axis perpendicular to its plane and passing through its centroid ; (b) when the disc is initially given a velocity of translation only. The equations of motions are stated, and approximate solutions given.

A. W.

5. *Elastic Properties of Bismuth Wires.* J. E. Harris. (Phys. Rev. 85. pp. 95-119, Aug., 1912.)—On investigating the elastic properties of bismuth wires, it was found that they exhibit some of the peculiar properties possessed by the Pt-Ir wires examined by Guthe and Sieg [see Abstract No. 872 (1910)]. When the wires were vibrated torsionally a great decrease in the period of vibration and the logarithmic decrement was observed when the amplitude decreased. The curves for the Bi wires representing the relations between (a) the period and amplitude, (b) the logarithmic decrement and amplitude, and (c) the period and vibration number, were found to differ in some respects from those of the Pt-Ir wires, but the amplitudes in the case of the latter were greater in some cases than could be reached by Bi wires, because of the low elastic limit of Bi. It was found that in two experiments in which the mass of the vibrating system was kept constant but the moment of inertia varied, the period-amplitude curves in the two cases could be made to coincide by applying a reduction factor to the periods in one set of observations. This reduction factor was found to be equal to the ratio of the

square roots of the moments of inertia used in the two experiments. This indicates that the mathematical relation between the period and amplitude does not depend upon the rapidity of motion of the vibrating system. The log. decrement-amplitude curves in the two cases were found to coincide. When the load as well as the moment of inertia was varied, on applying the proper reduction factor to the periods the two curves did not coincide, the curve corresponding to the vibrating system having the smaller mass being flatter than the other. The greater values of the log. decrement were found in the case in which the suspended mass was greatest. On varying the length of the wire the results indicated that the period is the same general function of the amplitude in all cases. This also indicates that the wire is uniform throughout its length, and that its peculiar behaviour is not due to any particular section of the wire. Two wires of different diam. were arranged with suspended masses such that the stresses to which the wires were subjected were the same in each case. By applying the proper factors to the amplitudes and periods the curves could be made to coincide. The log. decrement curve for the smaller wire was found to lie above that for the wire of larger diam., indicating a greater damping effect in the former.

J. J. S.

6. *Experiments on the Strength and Fatigue Properties of Welded Joints in Iron and Steel.* T. E. Stanton and J. R. Pannell. (Inst. Civ. Engin., Proc. 188. pp. 1-81; Discussion and Correspondence, pp. 82-77, 1911-1912.)—The tests were partly suggested and guided by the Charing Cross roof failure of 1906, and aimed at getting an estimate of the value of welds by various makers and processes, relative to the unwelded materials. Tensile tests by Böhme, in Berlin, gave low efficiencies and small elongation and contraction of area for ingot irons, whereas tests by Huysfeld at Prevali showed efficiencies of 99 per cent., which are attributed by the authors to the elaborate mechanical treatment undergone after welding. Bauschinger in 1886 found lower efficiencies, but concluded that good mild-steel welds may be made with proper care in heating. The present specimens were submitted to complete static loading tests, the total elongation, e , being given by $a + bl$, where l = length, a and b constants. The first term is the local, and the second the general extension. The specimens were mapped in 1-in. gauge lengths, and the results give curves of extensions consisting of two parallel straight lines connected by an S-curve, the vertical intercept between these lines being the local extension. For alternating tests the Wöhler cantilever method was employed. As a result of preliminary tests it was concluded that Reynolds and Smith's speed effect on endurance does not apply to the apparatus now used, so the tests were run at 2000 alternations per min. To ensure that the max. stress should occur at the centre of the weld the specimens were turned with a shoulder at that position, the wider part being held in the chuck, whilst they were made hollow to some distance beyond the weld to reduce the time occupied in the tests. It was sometimes necessary to predict the limiting range from a test in which fracture occurred after a moderate number of reversals of a material of which only one specimen was available. In such cases a standard endurance curve was obtained for a material of very similar properties, and it was assumed that the limiting range of the single specimen had the same ratio to the standard limit as did the range at the given number of reversals to that of the standard. The authors conclude that the local elongation is the best criterion of efficiency. The most important result is that although the welds

are locally brittle, as Bauschinger found, and give a small local contraction, that is not fatal to resistance to alternating stresses, a definite failure having in all cases been traced to a place in the joint where actual welding has not taken place. If 70 per cent. static strength be taken as the lowest limit of a good weld, the results show bad welds as follows:—5 in 21 hand-welded steel, 2 in 24 hand-welded iron, 1 in 8 electric-welded steel, 0 in 7 electric-welded iron. Acetylene-welded joints are uniformly worse than any others. The electric method gives the most uniform results. The slight inferiority of electric- compared with hand-welds to resist fatigue may be due to the particular practice of the maker and not to the general process. As a broad conclusion the subjection of each weld in a structure to a proof-load is suggested. In the *discussion*, Stanton mentioned further tests showing no advantage from annealing. Further, 1½-in. bars welded and then forged down to ¾-in. gave results comparable with the Prevali figures, showing that mechanical working helps to obtain a perfect weld. E. Matheson pointed out the suitability of electric welding for the hardware and small trades handling many duplicates where the cost of special jaws and accessories is distributed. The dangers of sulphur in a coke fire limited the use of steel for ordinary welding; it was not found in crane-chains or draw-bars. Metal for welding must be puddled and not originate in a cast ingot. C. E. Strohmeyer objected to the recommendation of a proof-load without so treating the test specimen: they might thereby be seriously injured. Welds should not be used in structural ties. He suggested placing the shank of the test-piece entirely outside the weld and distributing the stress uniformly over the latter by turning it taper. He suggested the formula $S = F + C\sqrt{(10^6/R)}$, where S = stress, F = fatigue limit, R = revolutions, and criticised the use of the standard curve. W. White would avoid welds in tension members if possible, and would use a proof-load. He had observed "rotting" of metal around welds. W. G. Kirkaldy described his own tests. He agreed with Böhme that ingot iron should not be welded. The Prevali tests were of little value as the mechanical working was ordinarily impracticable. Many bad welds were caused by making the "scarf" concave so as to make a neat joint externally but hollow inside. The boring-out of the test specimens might have removed this faulty part, giving too favourable results. The spreading of initial unsoundness was more to be feared than damage from heat-treatment. R. Appleyard described the welding of iron and steel sheathing-wire for submarine cables. The presence of impurities made hand-welding impracticable; electric welding gave a perfect joint, but there was always a weakness due to molecular changes in the material. He suggested the recording of the rate of loading in the tests to eliminate the inertia factor of the testing machine. P. B. Brown mentioned that aluminium is fatal to hand-welding. C. H. Wingfield criticised the taking of equal tensile and compressive stresses in the fatigue tests. He suggested that, for welds as for other materials, the safe range decreases, as the upper limit of stress is raised, according to a linear law. He suggested the location of welds in steel by a magnet deflection method, and described an arrangement of induction coils with a telephone receiver for the same purpose. J. O. Arnold objected to the Wöhler test as not investigating the factors of rapidity of loading and contingencies. W. Beardmore recommended annealing after welding to relieve the local brittleness. The steel should be heated to the refining temperature, cooled in the air to the A_1 point, and thence cooled slowly in the furnace.

E. J. S.

7. The Strength of Struts. R. V. Southwell. (Engineering, 94. pp. 249-250, Aug. 28, 1912.)—Practical experience shows that Euler's strut formula is sufficiently accurate if the conditions assumed hold true, namely, that the strut is initially straight; that loading is truly axial; and that the length is so great that the thrust cannot produce elastic breakdown before flexure begins. No serious error is introduced by assuming the first two, but the third condition is not justified for any but long struts. The author amends the theory to take account of elastic yield as revealed by a compressive stress-strain diagram for the material. If the material be stressed to a point beyond the elastic limit and the load is taken off, the diagram follows a line parallel to the original line of elastic strain, i.e., the ratio (decrease of stress)/(decrease of strain) = E , the modulus of elasticity. But, if the load be increased, that ratio has a much smaller value, E' , given by the slope of the stress-strain curve. E' has a value depending on the load at which instability commences. The effect of distortion is to relieve the strain on one side of the axis where the "apparent modulus" is E and to increase it on the other side, the modulus being E' . Thence, although the conservation of plane sections may be assumed, the centroid of stress no longer coincides with the centre of area. The case of a rectangular strut of breadth $2l$ and depth a is considered. The centre of stress is located by the consideration that the total action remains unchanged. The bending moment is integrated over the two parts of the section, the ordinary theory of elastic bending being used. The resulting differential equation, obtained by equating to the external bending moment, is—

$$p \cdot y + d^2y/dx^2 \times \frac{1}{2} E l^2 [1 + \frac{1}{2}(1 - E'/E)(b^2/l^2 - 8b/l - 2)] = 0 \dots (1),$$

where y is the deflection of the centre of area from its initial position, p is the intensity of compressive stress on the section just before collapse, x the distance of the section from one end, and b the eccentricity of the centre of stress. Euler's equation reads—

$$p \cdot y + d^2y/dx^2 \times \frac{1}{2} E l^2 = 0 \dots \dots \dots (2).$$

If l is the length of strut, calculated from equation (2), which will just support stress p , and l' is the length from equation (1), then l'/l reduces to $2/[1 + \sqrt{(E/E')}]$. This simple relation holds for rectangular sections, but similar results may be deduced for other sections by making suitable approximations. Plotting E'/E against l'/l for rectangular, solid round, and thin tubular sections shows that for medium lengths the form of section has no serious influence, though the small variation found confirms Lilly's experimental work. Curves are given of collapsing stress against length/radius of gyration as derived experimentally by Lilly, together with the latter's empirical Rankine-Gordon curves. Further curves show the result of using Euler's theorem and the present theory. It is seen that the last shows a much closer approximation throughout to practice than do any of the others. The new theory, moreover, demonstrates a temporary reappearance of stability in the region of the yield-point, which was clearly shown in Lilly's tests.

E. J. S.

8. Stress Distribution in Drilled Tie-rods. E. Preuss. (Zeitschr. Vereines Deutsch. Ing. 56. pp. 1780-1788, Nov. 2, 1912.)—Designers often make the erroneous assumption that the stress-distribution on the sections of a tie containing a hole is uniform. Kirsch and Föppl have shown

theoretically for an infinitely broad rod that the stress at the edge of the hole is independent of the diam., and equal to about three times the value calculated on the assumption of uniform distribution. The present tests were made on specimens all 120 mm. wide, with holes of 15, 30, 50, and 70 mm. diam. An axial tensile load was applied by means of bolts passing through the specimen, being placed far enough apart to ensure uniform stressing above and below the hole at the centre. The load was in each case so adjusted that, if it were uniformly distributed over the transverse section containing the centre of the hole, the stress would be 1000 kg. per sq. cm. Stresses are deduced from strain measurements by an optical apparatus [see Abstract No. 1488 (1912)], the datum length being 8.8 mm., and readings being correct to 5 %. Owing to the curvature of the stress lines round the hole, it is not sufficient to measure only axial strains at a number of points along the central plane; strain measurements at right angles have to be made simultaneously. If s_1 and s_2 are the longitudinal and lateral strains measured, E = Young's modulus, σ = Poisson's ratio, f_1 and f_2 = longitudinal and lateral stresses at the point, then—

$$f_1 = E\sigma(s_1 + s_2)/(\sigma_2 - 1), f_2 = E\sigma(s_1 + \sigma s_2)/(\sigma^2 - 1).$$

Both stresses are tensile. In each case the area under the diagram of longitudinal stress plotted on the section should equal the rectangle contained by the sectional area and the "mean stress" of 1000. It is found that the agreement is rather erratic, the error varying from -1.7% to $+12.8\%$. In general the stress falls from a very sharp maximum at the edges of the hole, but with smaller holes the curve descends very gently after passing the mean stress line, and with large holes the curvature varies but little. The magnitude of the maximum varies irregularly from 2.18 to 2.85 of the mean, but appears to be independent of the diam. of the hole. The minimum stress decreases steadily from 87.2 % to 52.0 % of the mean with increase of diam. from 15 mm. to 70 mm. E. J. S.

9. *Law of Equivoluminal Oscillations in Metals.* W. Peddie. (Engineering, 94, p. 550, Oct. 18, 1912. Paper read before the British Assoc., at Dundee, 1912.)—The case considered is that of the torsional oscillations of a wire, which is the simplest condition accompanied by no change of volume. The oscillations are set up in the wire, less than 1 ft. long, by means of a torsion head, so that no pendulum vibrations are set up. The load at the free end is a brass ring with a number of brass pins arranged at equiangular distances in a circle on its lower face. As the ring oscillates in a horizontal plane, the pins make contact with radial mercury pools in an ebonite disc. The angular interval of the pools is different from that of the pins, so that the Vernier principle is employed. The making contact at various stages of an oscillation actuates needles by means of electromagnets, perforating a travelling squared card. Thus chronographic records are obtained of the instants of attainment of successive angular positions at intervals of 2° . Tests of iron and steel, where Hooke's law is closely obeyed, show that vibrations are simple harmonic. Isochronism is lost with viscous metals such as copper, zinc, and lead, a large oscillation having a longer period than a smaller one. The time of inward swing from the max. angular displacement to the centre is distinctly longer than the time of swing to the next maximum. The displacement-time curve exhibits a point of contrary flexure corresponding to the position of set. If a simple harmonic curve be taken with its point

of contrary flexure coinciding with the position of set, and its maximum coinciding with the maximum beyond that position of set, then it is found that the experimental return curve practically coincides with the former through all phases up to a displacement equal to that of the position of set and on the other side of the zero point. A rapid deviation occurs in the remainder of the outward swing, an earlier maximum being attained at a smaller displacement. It is thus found that the simple harmonic law holds for the greater part of a semi-oscillation even when the viscosity is so great as to reduce the amplitude to one-third in a semi-oscillation. This correspondence was unexpected, and afforded an interesting comparison with J. Wiedemann's theory that the loss of energy in a vibrating wire is due to work of distortion in passing from one to another position of set. E. J. S.

10. *Investigation of Stresses in Riveted Joints and their Effect in causing Tearing at the Holes.* C. Bach and R. Baumann. (Zeitschr. Vereines Deutsch. Ing. 56. pp. 1890-1895, Nov. 28, 1912. Communication from the Materialprüfungsanstalt d. Kgl. Techn. Hochschule, Stuttgart.)—The force, Q , with which the rivet holds the plates together is determined by carefully measuring the overall length in the joint, then turning the plates away in a lathe so that the rivet falls out. Q being now released, the rivet shortens by a measurable amount, which is reduced in proportion to the length of the shank. The influence of the strengths of the heads introduces a small error into the calculation of Q on this basis, which is incommensurable but negligible when accidental variations of elasticity, etc., are remembered. The use of a red-hot screw and screwed head in place of a rivet, equivalent to zero pressure in the ordinary machine, gave a stress for Q near the lower elastic limit of the rivet, whilst moderate pressures in the press give about the same figure. The customary high pressures give a small falling-off of Q due to the severe overstraining of the plates. With well-bedded flat plates the cooling of the rivets suffices to give a good joint. The force employed should only be just sufficient to form well-shaped heads and to press the plates together if they have a tendency to spring apart. For the rivets used, 2.8 cm. diam., a force of 40,000 to 50,000 kg. causing a stress of 6000 to 8000 kg. per sq. cm. of rivet is found to be ample. To avoid the detrimental effects of excessive pressures it is desirable to make the plates bed together well, e.g. in boilers by carefully bending to the same radius. High pressures cause the material of the plates to flow under the rivet-heads. The latter sink in and the plates spring apart near the caulking edges. The stresses due to overstraining combined with thermal stresses cause radial cracks to start from the holes: these are plainly seen in photographs reproduced. The period during which steady pressure is applied is found to be of importance only when the plates tend to separate. In the latter case 1 minute is found to be sufficient (with the die not cooled), to give the rivet sufficient strength to draw the plates together. It is found that the holding power is increased by increasing the length of the rivet. This is explained from the fact that the rivet-heads take up a larger proportion of the axial strain in short rivets than they do in long. The best result is obtained with a stress near the lower elastic limit of the rivet, when the length is made equal to 8 diameters. With greater lengths overstraining follows in the plates. Tests were made of rivets only heated at one end for closing the heads. The holding stresses are found to be of the same order as with wholly heated rivets. But several heads broke away from the shanks and there were evidences of severe local over-heating strains. The evil effect of local heating was shown by breaking tests

on bars of the rivet material. Bars which had cooled after local heating were uniformly weaker than those heated throughout. It was particularly noticeable that the former showed only 19.9 % elongation, as compared with 28.2 % by the latter. The locally heated rivets, by unequal contraction, also caused severe damage to the plates. E. J. S.

11. *Absorption of Gravitation.* W. de Sitter. (Observatory, 85, pp. 387-398, Nov., 1912.)—The writer gives a review of a pamphlet recently published by K. F. Bottlinger, of Munich, on the "Theory of Gravitation and Motion of Worlds," in which the possibility of an outside influence on gravitation is shown to be within the bounds of probability. Bottlinger finds that there is an absorption or extinction of gravitation when a material body intervenes between two bodies whose mutual action is being considered, e.g. the gravitational pull of the sun on the moon may be diminished during a lunar eclipse by the intervention of part of the earth. A short outline of the analysis is given, with curves, showing the interesting nature of the perturbation found, this being in the form of an irregular curve having alternate maxima and minima with approximate periods of 18 years. Superposed there appears to be a longer period, possibly connected with the known cycle of 278 years. Some work on the same subject by Sitter is given in comparison. C. P. B.

12. *Exit of a Projectile from a Mortar.* (U.S. Artillery, Journ. Sept.-Oct., 1912. Engineering, 94, pp. 718-719, Nov. 22, 1912.)—Six photographs taken by the Department of Enlisted Specialists, U.S. Coast Artillery School at Fort Monroe, illustrate the exit of a projectile from a mortar, and the peculiar smoke cloud, which the projectile overtakes and which sometimes encircles the gun like a ring. The photographs evidently represent not successive stages of the same discharge, but successive moments of different discharges, though this is not stated in the original report. H. B.

13. *Resistance to Air Flow in Pipes.* A. H. Gibson. (Engineering, 94, p. 708, Nov. 22, 1912.)—Mentions previous paper by the author and J. H. Grindley [see Abstract No. 554 (1908)] which gave results at variance with commonly accepted laws. It appears that any formula of the form $dp = f v^2 / 2 g m$ can only hold when f is varied to suit the physical condition of the interior surface of the pipe and its diameter as well as the mean pressure, temperature, and velocity of flow. The theory of dimensions gives an equation of the form $dp = k p^{n-1} \cdot v^n \cdot \mu^{m-n} / [a^n \cdot d^{2-n} \cdot (cr)^{n-1}]$, where k and a are numerical constants, p and v are the mean absolute pressure and velocity in the pipe, μ is the viscosity and r is the absolute temperature; c is from the equation $pV = cr$ and equals 11.9 when unit mass is 1 lb., d is the pipe diam. and n is a numerical index. The experimental results of Riedler and Gutermuth, of Brix, Stookalper, and of the author are analysed and show good agreement with the dimensional equation above. The index n may in the case of ordinary cast-iron pipes be assumed to have the values 1.88, 1.81, 1.79, 1.78, 1.77 when the diam. is 3, 5, 7, 9, 12 in. respectively, and for all cases of flow where the air is at atmospheric temperature (about 65° F.) the drop in pressure is very nearly $dp = 0.00000125(p^{n-1} \cdot v^n \cdot \mu) / (6.6^n \cdot d^{2-n})$ lbs. per sq. in. H. S. R.

14. *Steady and Turbulent Motion in Gases.* J. J. Dowling. (Roy. Dublin Soc., Proc. 18. 26, pp. 375-398, Nov., 1912.)—A new method of investigating VOL. XVI.—A.—1918.

the varying conditions of flow of gas through a tube is described. The gas passing through the tube is ionised by the action of radium bromide at a certain point, the rest of the tube being screened from the rays by a block of lead. The gas passes into an insulated metal cylinder connected to the negative pole of a battery of about 200 volts. A wire passing through the side of the cylinder and insulated from it is bent so as to lie on the axis; its other end is connected to one pair of quadrants of a Dolezalek electrometer, the other pair of quadrants and the positive pole of the battery being earthed. The charge acquired by the wire is a measure of the ionisation of the air reaching the cylinder. Plotting curves for the variation of this residual conductivity with the rate of flow of gas through the tube, it is found that the conductivity at first increases smoothly (as would be expected for stream-line flow) with the velocity, but at a certain velocity for any particular tube there is a well-pronounced discontinuity. After this occurs the curve may continue to show an increase of conductivity with velocity, as before, or, in some cases, a decrease. This discontinuity corresponds to the commencement of turbulent flow. Various glass and copper tubes were experimented with. For the glass tubes the mean value of the constant $K = \rho V_c d / \eta$ is 2481; ρ being the gas density, η its coefficient of viscosity, V_c the critical velocity, and d the diameter of the tube. Hence Reynolds' formula becomes $V_c = 1240\eta/\rho a$, where a is the radius of the tube. The corresponding result for copper tubes is $V_c = 1560\eta/\rho a$. The value of the constant is in each case higher than Reynolds' value for water, but it is remarkable that the difference is only, at most, about 50 per cent. The dependence of the critical velocity on density and viscosity was also investigated, CO_2 being used. In several cases a second critical stage was discovered, the curves showing two marked discontinuities. The relation between the second critical velocity and the tube diam. is $V_c = 28.6(d + 0.6)$, the points lying very close to this straight line. Three possible explanations of this second critical velocity are suggested, the most probable of these being that it is due to something in the nature of "slip." This view is supported by experiments on the skin friction of air flowing in tubes.

A. W.

15. *Laws of Fluid Flow.* V. Kaplan. (Zeitschr. Vereines Deutsch. Ing. 56. pp. 1578-1586, Sept. 28, 1912.)—Recent literature on fluid flow shows the tendency to treat two-dimensionally problems formerly treated one-dimensionally. Even the velocity potential is imperfect to describe actual phenomena, and the current method of estimating frictional losses as a percentage of the total head is not without fault. The author discusses mathematically the flow of liquids, especial regard being paid to the effects of viscosity and boundary friction. Instead of the Newtonian assumption for viscosity and its consequent equation $\tau = \mu \cdot dv/dz$ the author uses $\tau = \mu' sv \cdot dv/dz$, where τ = shear stress, μ and μ' are viscosity constants, and s is the co-ordinate perpendicular to the shear planes. This second equation seems to fit practical results better than the first. The author applies it to the flow in a parallel canal and draws lines of force and isotachs or isovels for a rectangular section. The energy increment from layer to layer increases as the boundary becomes nearer, except at the boundary where it is zero. It increases with the length and roughness of the canal but decreases as the mean flow increases. An analogy from the mathematical flow of heat is considered, and the similarity of temperature and velocity distribution pointed out. Experiments are then described which support the theory.

H. S. R.

16. *Motion of a Viscous Fluid under a Rotating Plate.* H. Sanders. (Deutsch. Phys. Gesell., Verh. 14. 16. pp. 799-805, Aug. 30, 1912. Extract of Inaug. Dissertation, Erlangen, 1912.)—The liquids dealt with were paraffin and distilled water; the circular disc was rotated on the surface of the liquid at various uniform speeds by means of an electric motor; and the shearing deformation of the liquid was investigated by means of a number of thin straight metal rods secured at their middle points by elastic threads, as in Reiger's experiments [Abstract No. 807 (1910)]. Curves are reproduced showing the effect of increased angular velocity of the plate, of depth of liquid, of the dimensions of the rods, and of the width of the containing vessel. Turbulent motion is also considered. At small angular velocities of the plate it is shown that a linear relation exists between the velocities of the particles of the fluid and their distance from the bottom; but for large velocities complicated results are obtained which are not altogether explained by the assumption of the commencement of turbulent motion. A. W.

17. *Formation of Sand Dunes.* P. Hahmann. (Ann. d. Physik, 89. 8. pp. 637-676, Oct. 15, 1912. Inaug. Dissertation, Bonn.)—An investigation of the formation of ripple-marks, sand dunes, etc., by uniform streaming of water or wind. The first part deals with earlier researches; the second gives the results of the author's own experiments, and the last discusses the subject theoretically. The results may be summarised as follows:—(1) The distance apart of ripple-marks increases proportionally with the velocity of the water which forms them. (2) The distance also increases with the size of the grains, but whether the relation is linear or not is not decided. (3) The distance apart increases with increasing temperature, apparently being proportional to it. (4) The distance decreases with increasing concentration of the salt solution. With higher concentrations the distance decreases more rapidly. Effects (3) and (4) are shown theoretically not to be due to density variations of the fluid, but to internal friction. (5) The investigations with air currents also gave an increase of the distance apart proportional to the velocity. (6) With water it was found that the distance apart increased with the size of the grains, but with wind the reverse was the case. A theoretical explanation of this is given, based on Helmholtz's eddy theory. A. W.

18. *Foundation of a Theory of Matter.* G. Mie. (Ann. d. Physik, 89. 1. pp. 1-40, Sept. 5, 1912.)—Highly analytical paper in continuation of previous one. The present communication is concerned with electron problems and the point singularities of the fields (*Knotenstellen der Felder*). One part of the analysis leads to the conception of alternately positively- and negatively-charged concentric spherical shells like the layers of an onion. Between two shells, near the zero equipotential surface, there is a more or less extensive region in which the electric atmosphere is extremely rare, and in which a field exists as in a concentric spherical shell condenser. Near the centre of the system the *onion layers* crowd closer and closer together, and electric density, potential, and field between two shells all increase without limit. [See Abstract No. 762 (1912).] E. H. B.

19. *Theory of Relativity.* R. D. Carmichael. (Phys. Rev. 85. pp. 158-176, Sept., 1912.)—In the theory of relativity the word *postulate* has been used in the sense in which one is accustomed to employ the term *law of nature*. The present paper contains an analysis of the postulates of relativity. It was
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undertaken in order to ascertain on just which of the postulates certain fundamental conclusions of the theory depend. The importance of this may be seen as follows. Some of the conclusions of relativity have been attacked by those who admit just the parts of the postulates from which the conclusions objected to can be derived by purely logical processes. It is here sought to establish some of the most fundamental and most readily accessible conclusions of the theory on the smallest possible foundation from the postulates. This plan of treatment, instead of giving rise to more complicated arguments than those hitherto usually employed, has had the opposite effect of leading to increased simplicity both in the notions which enter and in the arguments by which proofs are reached. In the early part of the work it was found that some of the most striking conclusions of the theory depend on only a part of the postulates. To bring this fact prominently into view is to put the whole subject in a clearer light where we may see better the interactions of its parts and its general relations to the whole body of scientific and general knowledge.

Writers on relativity have usually stated two postulates only, but have tacitly, and in some cases perhaps unconsciously, made further assumptions. These are here stated at the outset, and then other postulates and theorems obtained as indicated below, the whole forming a simple introduction to the entire subject.

Postulate H_1 .—Space is homogeneous and three-dimensional.

Postulate H_2 .—Time is homogeneous and one-dimensional.

Definition of S .—Consider any set of things consisting of objects and any kind of physical quantities whatever, each of which is at rest with reference to each of the others. Suppose these objects include clocks and rules, *i.e.* time and length measures. Such a set of objects and quantities, at rest relatively to each other, together with their units for measuring time and length, are called a *system of reference*, and will be denoted by S ; or, if there are several, by S_1, S_2 , etc. Further, it is assumed that the units of any two systems S_1 and S_2 are such that the same numerical result will be obtained in measuring with the units of S_1 a quantity L_1 and with the units of S_2 a quantity of L_2 , when the relation of L_1 to S_1 is precisely the same as that of L_2 to S_2 .

Postulate M .—The unaccelerated motion of a system of reference S cannot be detected by observations made on S alone, the units of measurement being those belonging to S .

Postulate R' .—The velocity of light in free space, measured on an unaccelerated system of reference S by means of units belonging to S , is independent of the unaccelerated velocity of the source of light.

Theorem I .—The velocity of light in free space, measured on an unaccelerated system of reference S by means of units belonging to S , is independent of the direction of motion of S . (MR' .) (The letters in brackets after any theorem here and hereafter indicate the postulates on which it is based and from which and the H 's it may be derived by purely logical processes. The postulates H_1 and H_2 are not separately inserted after each theorem as they underlie all.)

Postulate R'' .—The velocity of light in free space, measured on an unaccelerated system of reference S by means of units belonging to S , is independent of the absolute value of the velocity of S .

Postulate R consists of the combination of R' and R'' and thus often affords an abbreviated reference.

Theorem II .—The velocity of light in free space, measured on an un-

accelerated system of reference S by means of units belonging to S , is independent of the velocity of S . (MR.)

The second postulate of relativity has usually been stated in a form different from that given above in R' and R'' or R . In fact, the truth of Theorem I. has often been taken as part of the *assumption* in this postulate notwithstanding that I. can be derived from M and R' . Now it is precisely the supposed assumption of I. that has given most difficulty to some persons. It is believed part of this difficulty will disappear in view of the fact that I. is here demonstrated from M and R' , which are probably accepted by those who found difficulty in Theorem I.

Postulate V.—If the velocity of a system of reference S_2 relative to a system of reference S_1 is measured by means of the units belonging to S_1 , and if the velocity of S_1 relative to S_2 is measured by means of the units belonging to S_2 the two results will agree in absolute value.

This velocity is called the *relative velocity* of the two systems and its direction line the line of *relative motion*.

Postulate L.—If two systems of reference S_1 and S_2 move with unaccelerated relative velocity, and if a line segment l is perpendicular to the line of relative motion of S_1 and S_2 and is fixed to one of these systems, then the length of l measured by means of the units belonging to S_1 will be the same as its length measured by means of the units belonging to S_2 .

The usual relations of relativity as to measures of time and space in two systems are then obtained.

E. H. B.

20. *Surface Tension of Solutions and Suspensions of Soap.* F. Bottazzi. (Accad. Lincei, Atti, 21. pp. 865-878, Oct. 18, 1912.)—The surface tension of water, in which is suspended sodium or potassium stearate, does not differ from that of pure water. The gradual addition, drop by drop, of $N/20$ NaOH to a solution of sodium oleate first decreases its surface tension to a minimum, the partial suspension being transformed into a perfect solution; further addition of NaOH slightly increases the surface tension. Addition of $N/50$ NaOH to a dialysed 2 % solution of potassium oleate decreases the surface tension steadily until 40 drops have been added per 15 c.cm. The surface tensions of dialysed solutions of sodium and potassium oleates are diminished by the addition of $N/20$ KOH and NaOH respectively, minima being reached, beyond which the addition of alkali increases the surface tension. If after the surface tension has thus increased $N/50$ HCl is added, it again falls to a minimum, and then commences to rise with further addition of HCl. The addition of $N/1$ NaOH to a 6 % solution of sodium oleate first increases the surface tension, which after reaching a maximum, gradually falls, the solution remaining perfectly limpid, but becoming very viscid. The results are attributed to the effect of NaOH in first retarding hydrolytic dissociation, and then in tending to precipitate soap.

W. H. Si.

21. *Instrument for Registering Rectangular Co-ordinates.* (Pat. No. 284,868 of 1910. Zeitschr. Instrumentenk., Beib. 19. p. 207, Oct. 1, 1912.)—Describes, with sketch, the apparatus, which is made by Hartmann and Braun. A. W.

22. *Theory of the Anschütz Gyroscopic Compass.* O. Martienssen. (Zeitschr. Instrumentenk. 82. pp. 809-821, Oct., 1912.)

23. *Effect of Temperature and Chemical Nature of Liquids on the Viscosity for Turbulent Flow.* W. Sorkau. (Phys. Zeitschr. 18. pp. 806-820, Sept 1, 1912.)

24. Diffusion in Solids. C. H. Desch. (Chem. News, 106. pp. 158-155, Sept. 27; 168-170, Oct. 4; 178-181, Oct. 11, and pp. 191-198, Oct. 18, 1912 Report presented to the British Assoc. at Dundee. Engineering, 94. p. 588 Oct. 25, 1912. Abstract.)—The subjects discussed are : Diffusion in Glasses and Devitrification ; Electrolysis of Glass and Porcelain ; Diffusion of Gases through Metals ; Passage of Liquids through Metals ; Solid Diffusion in Metals ; Cementation and Decarburisation of Iron ; Segregation and Recrystallisation ; Influence of the Amorphous Modification in Metals ; Electrolysis of Crystalline Solids ; Diffusion in Minerals ; Diffusion in Artificial Crystals ; Diffusion in Colloidal Gels ; Liesegang's Phenomena. Those who are interested in the topics discussed are advised to consult the original report. T. M. L.

25. Application of Kinematography in Shock Tests. W. Höniger. (Zeitschr. Vereines Deutsch. Ing. 68. pp. 1501-1505, Sept. 14, 1912.)—The author has applied a moving photographic film to the determination of the force absorbed in impact tests. F. C. A. H. L.

26. Hysteresis of Suspensions. O. Venzke. (Ber. über d. Tätigkeit d. Kgl. Preuss. Meteorol. Inst. i. J. p. 129, 1912. Zeitschr. Instrumentenk. 82. pp. 880-881, Oct., 1912. Abstract.)—Discusses the creep or after-working phenomena of fibre suspensions and gives detailed instructions for reducing these disturbances to a minimum. E. H. B.

27. The Brownian Movement and the Size of the Molecules. J. Perrin. (Chem. News, 106. pp. 189-191, Oct. 18; 208-206, Oct. 25, and pp. 215-217, Nov. 1, 1912. Paper read before the Royal Inst., Feb. 24, 1912.)

28. Resistance to Motion of Body in Fluid. T. v. Kármán. (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 5. pp. 547-556, 1912.)—Mathematical paper dealing with the mechanism of this fluid resistance. E. H. B.

29. Longitudinal and Transversal Masses. P. Frank. (Ann. d. Physik, 39. 8. pp. 698-708, Oct. 15, 1912.)—Derives formulæ for the masses at high speeds by energetics. E. H. B.

30. Evaporation from the Soil and Plants. A. Müntz. (Comptes Rendus, 155. pp. 519-521, Sept. 9, 1912.)—Periods of long rainfall tend to persist as in 1910 and 1912. At the *Station de Chimie Végétale* at Bellevue 218 m.³ of water evaporated from the soil per hectare during the month of July, 1910 ; the evaporation from a field of lucerne was 808 m.³ and the rainfall 697 m.³ per hectare in the same period. In Aug., 1912, there were 894 m.³ of rainfall and 900 m.³ of water evaporated from the lucerne field per hectare. The evaporation from the plants is thus much stronger than from the soil. It has also been observed that a soil from which strong evaporation is taking place is 2° or 3° C. colder than other soil, and the air which circulates through the leaves of the lucerne is 8° colder than the air above the plants. H. B.

31. Seismological Investigations. J. Milne. (Engineering, 94. p. 551, Oct. 18, 1912. Abstract of paper read before the British Assoc. at Dundee.)—The paper forms the 17th report of the B.A. Committee on Seismological Investigations, and contains a catalogue of all the earthquakes of the last 11 years. The author's investigations show that the amplitudes of the
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angular displacements in earthquake movements first decrease uniformly with the distance from the origin up to a distance of 80° , then less rapidly, and remain almost constant beyond 120° . Periods of megaseismic activity are followed by periods of quiescence, large groups of earthquakes being succeeded by periods of rest of from 15 to 80 days. There are no indications of seasonal variation, but there is evidently a connection between the geographical distribution of megaseisms and the thermometric gradients. In general there is four times the activity beneath the cold waters of some oceans than there is beneath the continents. Unfortunately there are few records as to temperature gradients, and hardly any for the soil beneath the sea. Probably heat is lost at ocean floors about $8\frac{1}{2}$ times as fast as at continental surfaces. From a comparison of the behaviour of cooling slag with volcanic dykes and fissures, Milne suggests that, with our earth, it was not the nucleus which contracted to leave a shell to follow downward, but a forming shell which contracted, and by its sudden grip on the unshrinking nucleus fractured itself.

A. D. R.

32. *Earth-tides*. T. Shida. (Mathematico-Physical Soc., Tokyo, Proc. 6. 18. pp. 278-275, July, 1912.)—The author corrects for the tidal displacement of the observing station the value given in a previous paper [see Abstract No. 1880 (1912)] for the lunar disturbance of the earth's potential.

A. D. R.

33. *Orientation of Photographic Equatorials*. E. Esclançon. (Comptes Rendus, 155. pp. 698-696, Oct. 14, 1912.)—Mention is made of the possibility of error in the making of region photographs with a photographic equatorial by merely following on a guiding star. If a small area round the guide star is considered, this area will be continuously deformed by differential refraction to a slight extent, depending on the altitude. An equation is given for calculating orientations which will reduce this deformation.

C. P. B.

34. *Mass of Saturn's Satellite, Titan*. H. Samter. (Preuss. Akad. Wiss. Berlin, Ber. 46. pp. 1051-1059, 1912.)—A review is given of results from previous calculations, and a new computation embodying recent determinations of position. The resulting value is $m^{-1} = 4172 \pm 58$.

C. P. B.

35. *Elements of Eclipsing Variable Stars*. H. N. Russell. (Astrophys. Journ. 86. pp. 188-155, Sept., 1912.)—In illustration of the methods proposed in former papers [see Abstract No. 1064 (1912)] details are given of the computation of the elements of the three eclipsing variables, W Delphini, W Ursæ Majoris, W Crucis.

C. P. B.

36. *Structure of Upper Solar Atmosphere*. H. Deslandres. (Comptes Rendus, 155. pp. 748-749, Oct. 21, 1912.)—In continuation of a former paper [see Abstract No. 1822 (1912)] the author gives a detailed discussion of various forms of solar disturbance photographed with the spectroheliograph at Meudon. From the examination of many plates it appears to be certain that alignments are elevated masses of material, and in general they show as prominences when projected at the solar limb. For the smaller prominences this connection cannot be completely established until more powerful apparatus with a larger image is available. Evidence is given to show the importance of a study of these features in relation to the solar

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atmospheric circulation. In explanation of the phenomena the effect of positive electrification is considered, with the added influence of the magnetic field which is now admitted to exist in many regions of the solar surface. This view explains without difficulty the complicated spiral and contorted structures presented by prominence matter during eruptions. From the opposite deviations of the matter of the filaments and that of the general upper atmosphere it appears that these have opposite electric charges, and we thus have also to consider the effect of an electric as well as a magnetic field. An interesting point is that on the above view the solar matter should be elongated from pole to pole; measures of the solar diameters, polar and equatorial, have at various times given evidence of such difference, but it has been so small that its reality could not be satisfactorily accepted. Thinking that any such effect might reasonably be more shown on the chromosphere, the author had a series of measurements specially made, and it was found that there was a systematic variation in the thickness of the chromosphere, the polar depth being greater than the equatorial; further, the difference was found to be variable from one place to another, and appeared greater for the southern hemisphere. C. P. B.

37. Systematic Motions of Sun-spots. Hirayama. (Coll. Sci. Journ. Imperial Univ., Tokio, Vol. 82. No. 7. Nature, 90. p. 178, Oct. 10, 1912. Abstract.)—From an analysis of the sun-spot motions given in Greenwich, Carrington, and Spörer catalogues, evidence is found of two sun-spot drifts. It is suggested that this may explain the distribution of sun-spots with different rotation periods. C. P. B.

38. Total Solar Eclipse at Vavau, April 28, 1911. A. L. Cortie. (Roy. Soc., Proc. Ser. A. 87. pp. 298-301, Sept. 19, 1912.)—The programme of observations organised by the Joint Permanent Eclipse Committee, consisted of (a) photographs of the corona on large and relatively small scales for coronal detail and extension of the streamers, (b) photographs of the spectrum of the corona and of the lower chromosphere. The weather conditions were very bad, the sun being surrounded with dense cirro-stratus clouds. With the 20-ft. coronagraph two plates show the lower corona in the immediate neighbourhood of the moon's limb, prominences being shown in position angle 240° - 258° , near the point of third contact. With the 84-in. coronagraph one good impression was obtained with an exposure of 25 secs. before third contact, the corona extending about one-half a lunar diameter, and several polar rays being visible. Only one spectrum photograph is of value, secured just before and at the time of the second flash, with the prismatic camera, and shows the hydrogen series from H_{α} to H_{δ} . C. P. B.

39. Helium and Coronium. A. A. Buss. (Observatory, No. 458. pp. 871-878, Oct., and p. 404, Nov., 1912.)—Observations of helium absorption by the dark D_2 line have been readily discernible over regions of faculae, but the author has found that on occasions of best definition the absorption may be seen at almost every point on the solar disc. The difficulties often found in seeing it are probably mainly due to motion of the image over the slit of the spectroscope, thus causing an integration of the spectrum of neighbouring parts of the sun. With regard to the corona the suggestion made by Wood some time ago is supported, that the phenomenon is one of fluorescence and not due to direct radiation. The author goes further and doubts the solar origin of the green line at 5808, thinking the green halo producing it may have a separate existence from the radiated outer coronal streamers. P. B.

40. Radium and the Chromosphere. S. A. Mitchell, J. Evershed. (Astronom. Nachr. No. 4600. Observatory, No. 458, pp. 887-882, Oct., 1912. Abstract.)—Mitchell has examined his eclipse chromospheric spectra and compared the results with the spectrum of radium given by Exner and Haschek. After discussing the various types of coincidence, which are given in tabular form, the conclusion is given that there appears to be no reason for ascribing any of the lines concerned to radium. The chief cause of the different opinions expressed by other workers would appear to be due to the different dispersive powers used, rendering ambiguous the correct allocation of the components of close groups of lines. Evershed points out that the apparent identification of radium lines with chromospheric lines becomes less probable when more determinations of eclipse spectra are used in the discussion. Detailed analysis is given of the alternative origins for each of the lines in question. Special mention is made of the Ra line near $\lambda 5818.9$, which region is almost blank in the solar spectrum, and might furnish a crucial test of the presence or absence of radium in the chromosphere. It is concluded that neither radium nor the emanation can be detected in the chromosphere by their spectra. **F. W. Dyson.** (Observatory, 85, pp. 402-404, Nov., 1912.)—Replying to the views expressed by Mitchell and Evershed, Dyson states that he attaches more importance than they do to the close correspondence of lines in the spectrum of radium with lines in the chromospheric spectrum. He also regards the chromospheric spectrum as not having a very close relationship to the solar (Fraunhofer spectrum), its agreement with metallic spark spectra being much closer because of the correspondence of the intensities of the lines. The question of close coincidences must not be taken alone, one of the additional criteria of value being the relative intensity of the spark lines of the elements in question, and especially if they be enhanced lines or otherwise. Dyson admits difficulty in accounting for the absence of any line at $\lambda 4828.10$ in Mitchell's spectrum; this and the presence of lines at $\lambda 4682.12$ (Ti) and $\lambda 4682.58(\gamma)$, whereas the radium line is $\lambda 4682.41$, somewhat weakens the case for radium. He hopes the line at 5818.9 mentioned by Evershed will be looked for at subsequent eclipses. C. P. B.

41. Balloon Shadows during Solar Eclipse. A. Wigand and E. Everling. (Deutsch. Phys. Gesell., Verh. 14. 15. pp. 748-757, Aug. 15, 1912.)—Photographs of the shadow of a balloon were taken during an ascent from Bitterfeld on the occasion of the partial solar eclipse, April 27, 1912. Diagrams are given showing the development of the shadow form by taking loci of projected shadows from each point of visible crescent, and three reproductions of the photographs are included. C. P. B.

42. Determination of Solar Motion. W. Dziwulski. (Acad. Sci. Gracovie, Bull. 7a, pp. 811-882, July, 1912.)—The elements of the solar motion are determined by Bravais' method, using parallaxes given by Kapteyn, Weersma, Pritchard, and Flint, radial velocities by Campbell, Küstner, Frost and Adams, Bólopolosky, Slipher, Newall, and Lord. Several different values of the velocity and co-ordinates of the apex are given, depending on the groups of observations employed. C. P. B.

43. Probable Identity of Comet 1912(b) with Tuttle's Comet. G. Fayet. (Comptes Rendus, 155, pp. 808-810, Oct. 28, 1912.)—The provisional elements of the new comet 1912(b), calculated by the writer with Schaumasse, were
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very similar to the accepted elements of Comet Tuttle, whose return was expected about this time. The differences between the two sets of elements are probably due to perturbations of the comet since its last apparition in 1899; in 1900 a close approach was made to Jupiter. C. P. B.

44. *Spectrum of Comet Gale (1912a)*. (Astronom. Nachr. No. 4608. Nature, 90. p. 288, Nov. 7, 1912. Abstract.)—Photographs of the spectrum of Gale's comet (1912a) at the Hamburg Observatory showed bands at $\lambda 887$, 474, 568. The continuous spectrum was relatively faint, but extended from $\lambda 887$ to $\lambda 568$. C. P. B.

45. *Parallax and Proper Motion of Nova Lacertæ*. Balanowsky. (Nikolai-Hauptsternwarte zu Pulkowo, Mitt. No. 52. Nature, 90. p. 178, Oct. 10, 1912. Abstract.)—Sixteen plates of the region of Nova Lacertæ were taken during the period Jan. 4, 1911, to Feb. 19, 1912. The values determined for parallax and proper motion were so minute as to indicate that these quantities were practically zero. C. P. B.

46. *Spectrographic Observations of Algol*. A. B  lopolsky. (Acad. Sci. St. P  tersbourg, Bull. 15. pp. 937-988, Nov. 1, 1912.)—From determinations of the radial velocity of the variable star system of Algol (β Persei) during the interval 1897-1911, the correction to the ephemeris time of minimum is determined. This is compared with the corrections determined by other means—the selenium photometer of Stebbins and the ordinary photometric methods. The values are greatest in amount for the selenium photometer (-76 m.), less for the ordinary methods (-70 m.), and least of all for the spectrographic method (-56 m.). It is pointed out that the three methods differ in that they employ different ranges of energy spectrum: the selenium photometer specially the red rays, the ordinary photometer the general visual rays, and the spectrograph utilising the violet rays. C. P. B.

47. *Determining Angular Diameters of Stars by Elliptically-polarised Light*. S. Pokrowsky. (Astrophys. Journ. 86. pp. 156-168, Sept., 1912.)—The method proposed is based on the consideration that between two rays arriving at any two points from any element of the surface of a distant source of light, there will always be a difference of phase depending on the distance between these points. For the various elements of the surface of the star this difference will have different values, from zero up to a certain limit determined by the magnitude of its angular diam. If we polarise all the rays which emanate from the star towards two points not very near together, and if we then superimpose them after turning the plane of polarisation of one of the bundles of rays through 90° , we shall obtain in general elliptically-polarised rays, if the difference of path be of the same order of magnitude as the wave-length of light. In the case of an infinitely small diam. the polarisation will be rectilinear. The alteration of 90° is made by interposing a half-wave plate in the path of one of the rays. The group of plane waves elliptically polarised are then passed through a doubly-refracting prism, and then observed by a telescope. An equation is derived from which the diam. of a star may be found if the distance between the two screen openings is known, and also the ratio of the intensities of the two polarised images. Two types of stellar interferometer adapted to this method of observation are then outlined. C. P. B.

LIGHT.

48. Long-focus Microscope. Study of Oxidation and the Phenomena of Development of Grain Joints and Division of Grains of Metals under Influence of Heat. F. Robin. (Bull. Soc. d'Encouragement, 118. pp. 204-281, Aug.-Sept.-Oct., 1912.)—With the object of studying the changes occurring in metals at various temperatures, the author has designed a microscope with a long frontal distance. Normally, such a microscope can only give low magnifications, but this difficulty has been removed by placing a double concave lens just outside the focus of the objective. By this means it is possible to obtain defined magnifications of 200 diams. with a frontal distance of 5 cm., which permits of the examination of metal sections during heating and cooling. The author has studied the rate of oxidation of the constituents of steel and other alloys at various temperatures, and has shown that at high temperatures a sort of local or corrosive oxidation takes place. At certain temperatures the joints of pure metals and solid solutions are developed quite sharply on heating, and at higher temperatures these grains split up into secondary grains.

F. C. A. H. L.

49. New Acuteness-of-Vision Photometer. R. Pauli. (Zeitschr. Instrumetenk. 82. pp. 294-297, Sept., 1912.)—The author describes a new form of acuteness-of-vision photometer. A white wedge is illuminated by the lamp to be tested, and this surface is observed through an eyepiece. Between the eye and the illuminated white area is placed a glass screen on which a diagram composed of very fine lines (0.007 mm. in diam.) is marked. The observer moves the photometer until the network of lines is just visible. Letters and figures have purposely been avoided, as the observer is apt to remember them and fancy that he can read them when he really cannot. The lines can be rotated so that the observer does not know their position, and is therefore not prejudiced by knowing exactly what he is going to see. In comparing two lamps, the observer merely moves the photometer backwards and forwards until the lines become perceptible and notes the distance from the source. The method is said to give satisfactory results, but allowance has to be made for the effect of adaptation on the eye.

J. S. D.

50. Absorption of Light in Solutions of Benzene and its Derivatives at Low Temperatures. J. de Kowalski and E. Banasinski. (Acad. Sci. Cracovie, Bull. 5a. pp. 416-485, May, 1912. Archives des Sciences, 84. pp. 216-288, Sept., 1912.)—The absorption spectrum of benzene shows fifteen bands. The "principal group" of six bands are equally marked at ordinary temperatures and at low temperatures. The second group consists of two bands which resemble the principal bands in their positions and properties, but one is sharp only at atmospheric temperatures and the other at low temperatures. Finally, there is a group of seven bands which are clearly visible only at the temperature of liquid air. The positions of the heads of the bands of the principal series are expressed accurately by the formula $1\lambda = 8852 - 91n$. A further regularity is seen in the fact that the heads of

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the bands of the solution at -192° are displaced towards the red by a constant number of vibrations ($1/\lambda$ decreases by 14 units) as compared with those in the spectrum of the vapour.

T. M. L.

51. *Limits of Uniformity in producing Optical Glass.* J. W. Gifford. (Roy. Soc., Proc. Ser. A. 87. pp. 189-198, Aug. 21, 1912.)—Determinations of the optical constants of 27 glass meltings by Schott, Parra-Mantois and Chance are analysed according to the procedure described in previous papers [Abstract No. 477 (1909)]. Three blocks were chosen at hazard from each melting and cut into approximately equilateral prisms, the surfaces being optically polished on all three sides. The mean refractive index for $\lambda 5270$ (E) was determined, the results being reduced to 15° C. All the values obtained are tabulated, from which it is shown that the heavy barium crown glasses are those which show the greatest variation in homogeneity in the same melting.

C. P. B.

52. *Diffraction Grating Method for Determination of Refractive Indices of Liquids.* F. A. Osborn and H. H. Lester. (Phys. Rev. 85. pp. 210-216, Sept., 1912.)—A new method is described for measuring refractive indices, based on the determination of the ratio of the wave-lengths in air and in the liquid, employing a Rowland plane grating of approximately 15,000 lines to the inch, and an Abbe spectrometer. The grating, which is completely immersed in the liquid contained in a double-walled metal tank, and mounted on the fixed circle of the spectrometer, receives the light from the objective and returns the diffracted light along the same path as the incident light. The temperature is controlled by a heating coil wound on the outside of the tank, the whole being wrapped with several layers of asbestos. Since $m\lambda = 2d \sin \theta$, the refractive index is determined, if d is constant, from the equation $\mu = \lambda_a/\lambda_w = \sin \theta_a/\sin \theta_w$, the subscripts referring to the air and liquid values respectively. Allowing for the change in temperature of the grating in the air and in the liquid, $\mu = (\sin \theta_a/\sin \theta_w) [1 + \alpha (t_1 - t_2)]$ approximately, where t_1 and t_2 are the respective differences in temperature between air and liquid readings, and that at which d_0 was determined, and α is the coefficient of expansion of the grating. The refractive index of water for the lines of Na, H, and Hg has been determined by the method, the results agreeing closely with those obtained by other investigators.

W. H. St.

53. *Influence of Temperature and Time on the Double Refraction of Strained Glass.* E. Zschimmer. (Archiv f. d. Physikal. Chem. d. Glases u. d. Keram. Massen, 1. Nos. 5 and 9, 1912. Zeitschr. Instrumentenk. 82. pp. 808-804, Sept., 1912.)—After a short summary of the observations made by Kerr and other investigators it is noted that hitherto the influence of temperature and the constitution of glass on the production of non-uniform double refraction by cooling, as well as the influence of temperature and time on the disappearance of stress and double refraction have been but little examined in a systematic way. Zschimmer has now made exact researches on 1-cm. cubes cut out of Jena glass and has especially sought to solve the following questions:—(1) For a given specimen of glass it must be ascertained how great is the value of the mean double refraction which is caused at various temperatures if the cube free from stress is suddenly brought from the region at P into a space at 20° , where it cools uniformly. (2) The thus ascertained curve of double refraction as function of the exciting and straining temperature t should for various glasses be

determined, and thereby it should be found what influence the chemical constitution of the glass has upon the course of the stress curve. (8) From one kind of glass several cubes are brought to a chosen value of the double refraction, and thus the times measured which are necessary to bring to a minimum the existing double refractions at various temperatures. (4) The curves of release of tension are determined for various kinds of glass in order to find the influence of constitution. In the present paper some provisional results are given and further experiments are being carried out. The method of heating is by the electric current, the oven being a porcelain tube 2 cm. wide. Boric acid crown glass (with 8.5 % B_2O_3) and ordinary flint glass (48.8 % PbO) from Schott's have been tested. The crown glass was decidedly more resistant against permanent deformation than the flint glass; the latter is much more plastic than the former. Crown glass required a much longer period for release from strain than the flint glass, the temperatures being the same. At 415° the time of recovery for flint glass was 4 hours, for crown glass 4 days. J. J. S.

54. Electric Double Refraction in Artificial Clouds. P. Zeeman and C. M. Hoogenboom. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 178-184, Sept. 8, 1912. Phys. Zeitschr. 18. pp. 918-920, Oct. 1, 1912.)—This is the third part of an account of investigations on sal-ammoniac vapour. The results obtained might be explained by supposing the existence of two varieties of sal-ammoniac crystals, and this dimorphism is a well-known fact. The phenomena previously described [see Abstracts Nos. 804, 662 (1912)] can be obtained with sublimated sal-ammoniac, so that the two modifications of the substance appear to exist after sublimation. The transition of one modification into the other may be accompanied by a change of the sign of the electric double refraction. Other methods were used for obtaining sal-ammoniac fogs: (1) A current of air was passed successively through bottles with a NH_3 solution and with a HCl solution. The tubes did not reach below the surfaces of the solutions. (2) Dried air was passed over heated, previously sublimated sal-ammoniac, and then introduced into the basin with exterior condenser plates. The air current and the heating of the sal-ammoniac being well regulated the putting on of the electric field caused a downward displacement of the band accompanied by a rotation of the plane of polarisation. After stoppage of the air current the band after a time exhibited the upward displacement. In some experiments the downward displacement could not be observed, and only a rotation was seen. This occurred especially with fogs of initially great density so that the field of view became dark. After partial precipitation of the fog the putting on of the field caused an upward displacement of the dark band. The results clearly point to the existence of two modifications of sal-ammoniac, the one first originated exhibiting a positive, the second a negative electric double refraction. Experiments show that the observed change of sign of the electric double refraction cannot be explained by a change of orientation of the particles constituting the fog. J. J. S.

55. Sharp Interference Bands with Wedge-shaped Plates. E. Gehrcke and L. Janicki. (Ann. d. Physik, 89. 2. pp. 481-488, Sept. 24, 1912. Communication from the Physikal.-Techn. Reichsanstalt.)—Describes experiments with wedge-shaped plates, which show that such plates will give very sharp interference bands, the curve for the intensity distribution having sharp maxima. Light incident on such wedge-shaped plates in a plane

perpendicular to the line of intersection of the two faces of the wedge, gives rise to a diverging or a converging beam according to whether it has a component away from or towards the apex of the wedge. The plane perpendicular to the line of intersection of the faces of the wedge is called the principal plane. For a given angle of incidence in the principal plane, the place where the emergent rays, whether diverging or converging, cut, is the farther from the plate, the smaller the angle of the wedge is. The diverging system will give rise to a system of virtual interference bands located behind the plate, the converging system giving real bands in front of the plate. These facts have been established, using partially silvered wedge-shaped plates of glass. Light from a mercury lamp (L) was condensed by a long-focus lens on to the wedge (W), a screen (S) receiving the transmitted light. Using the Hg 5460 line and a wedge of angle $0^{\circ} 1' 87''$ and average thickness 1.88 mm., the distances being LW about 140 cm., WS about 20 cm., an exceedingly sharp set of interference bands was obtained. Photographs are reproduced of this system and of that obtained with the total light from the mercury lamp; the latter system is also well defined. If the light is not incident in the principal plane the bands are no longer sharp, but merge into one another, the bands being less sharp the farther one goes from the principal plane, but these bands always remain parallel to the edge of the wedge. Besides these there are other diffuse bands inclined to the edge of the wedge. Plates with non-plane surfaces, when partially silvered on both sides, will give sharp bands. Using a weak convex lens (0.25 dioptre) with a plane glass plate, the surfaces in contact being silvered, the plano-concave air film gave sharp interference rings. Interference points were obtained and photographed by crossing a plane parallel glass plate 5.08 mm. thick and 20 cm. long (in a Lummer-Gehrcke interference spectroscopy) with the 1.88 mm. wedge. The wedge was in this case about 10 cm. from the slit of the interference spectroscopy so that the lens between the plate and slit was unnecessary. A fine adjustment for the wedge mounting was necessary to give the sharpest definition. In all cases the plates used were silvered by cathodic deposition, this giving the best results [see Abstract No. 759 (1911)]. Other experiments show that with the Lummer-Gehrcke arrangement it is more important to have the surfaces of the glass plate accurately plane than to have them absolutely parallel, since a wedge angle of only a few seconds simply has the effect of shifting the position of the plane of the interference bands. With two crossed wedges, a set of interference points is obtained, but the arrangement gives feeble illumination. The distance (D) of the interference plane from the wedge with varying angles of incidence (α) in the principal plane was investigated for two wedges. It is seen from the curves obtained that Feussner's formula $D = [\sin \alpha \cdot \cos^2 \alpha / (n^2 - \sin^2 \alpha)] \cdot d / \omega$ (where d is the thickness of the wedge, ω the wedge angle, and n the refractive index of the material) which holds for two rays in the principal plane, with sinusoidal intensity distribution, also holds for a large number of interfering rays. For the same two plates, for which $d = 1.77$ mm., $\omega = 0^{\circ} 2' 48''$; $d' = 1.88$ mm., $\omega' = 0^{\circ} 1' 87''$ respectively, the relation between the band width (s) and the angle of incidence (α) was investigated. The results agree well with Feussner's formula $s = [\lambda / 2\omega] \cos \alpha / \sqrt{n^2 - \sin^2 \alpha}$. Hence it appears that the position and the distance apart of the sharp interference bands due to many interfering rays, coincide with those for only two interfering rays with sinusoidal intensity distribution within the limits of experimental errors.

56. Emission Theories of Light. R. C. Tolman. (Phys. Rev. 85. pp. 186-148, Aug., 1912.)—The Einstein theory of relativity assumes that the velocity of light is independent of the relative motion of the source of light and the observer. An alternative postulate has been suggested—that the velocity of light and the velocity of the source are additive. Theories based on such a postulate may be called emission theories. It may be assumed that on reflection the excited portion of a reflecting mirror acts as a new source of light, and that reflected light has the same velocity with respect to the mirror as has the original light with respect to the source. The possibility of this assumption was formerly suggested by the author, but apparently disproved by an experiment on the velocity of light from the approaching and receding limbs of the sun. In the present paper further evidence is given disproving the possibility of the assumption. According to an emission theory suggested by O. M. Stewart light reflected from a mirror acquires a component of velocity equal to the velocity of the mirror image of the original source. The author brings forward evidence to disprove the possibility of such a principle. A very complete emission theory of electromagnetism has been presented by Ritz, which has perhaps not received the critical attention that it deserves. According to this theory light retains throughout its whole path the component of velocity which it obtained from its original moving source, and after reflection light spreads out in spherical form around a centre which moves with the same velocity as the original source. Now the Michelson-Morley experiment was devised for detecting the motion of the earth through the ether, and hence if this experiment should be repeated, using light from the sun instead of from a terrestrial source, a positive effect might be expected if the Ritz theory were true. But if the Einstein theory were correct no effect would be obtained. A definite experimental decision between the relativity theories of Ritz and Einstein is of great importance.

J. J. S.

57. Method for Measuring Speed of Light. C. Féry. (Comptes Rendus, 155. pp. 828-824, Oct. 28, 1912.)—To avoid the difficulty of evaluating the angular velocity of the ordinary rotating mirror in the classic determination of the speed of light, the author suggests the substitution of a mirror carried on the end of one prong of a tuning-fork. Light from a source at one side is directed on to a screen by a plane plate at an angle of 45° . Through a slit in the screen light passes to the mirror on the fork, back through the slit to a distant mirror, and returns. Then, when the fork is set in vibration, the original beam gives two displaced images AA' of the slit on the screen, due to the full motion of the prong. But two other images aa' at a less distance apart are also obtained, and these are due to the slightly displaced positions of the prong when the light has returned from the distant mirror. Thus, if the time occupied by this double journey is t , and the period of the fork T , we have $\sin 2\pi t/T = aa'/AA'$. Thus, for a double distance of 80 km. and $T = 0.002$ of a second, $t = 0.0001$, $aa'/AA' = \sin 18^\circ = 0.31$. So, if AA' were 20 mm., aa' would be of the order 6 mm. These two pairs of images could be photographed simultaneously, and so a considerable accuracy obtained.

E. H. B.

58. Extinction of Light by an Illuminated Retina. W. Abney. (Roy. Soc., Proc. Ser. A. 87. pp. 147-151, Aug. 18, 1912.)—An apparatus is described which enables the eye to observe a white disc, illuminated by white light, on which a sharp black shadow from a small opaque object is cast. The disc has

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a hole in it through which a plate illuminated by light from any desired region of the spectrum can be seen. The experiment consists in varying the intensity of the coloured light until the brightness of the coloured patch disappears and it matches the dark shadow. The white illumination can also be varied. Curves are reproduced showing how this extinction point varies throughout the spectrum for different values of the white illumination. It is interesting to observe that the point of minimum extinguishing illumination travels towards the red with the rising white illumination.

J. S. D.

59. Natural and Magnetio Rotatory Dispersion. T. M. Lowry. (Roy. Soc., Phil. Trans. 212. pp. 261-297, Oct. 28, 1912.)—This paper describes :—(1) A new test for the optical purity of quartz. (2) An accurate determination of the rotatory dispersive power of quartz for 24 wave-lengths in the visible spectrum. (8) Experiments to test the validity of Wiedemann's law. The author has found that the law holds good for quartz but not for optically-active liquids.

J. M.

60. Arc Spectrum of Iron. F. Goos. (Zeitschr. wiss. Phot. 11. pp. 805-816, Sept., 1912.)—In a previous paper [Abstract No. 866 (1912)] the wave-lengths of lines in the arc spectrum of iron between $\lambda 4282$ and $\lambda 5824$ have been given on the international system. The present paper continues the table for the lines from $\lambda 5828$ to $\lambda 6495$. Thirty-three plates have been employed for the measurements, ample overlap being allowed. Comparisons are given with the values determined by Kayser, and also a series of special comparisons of wave-lengths obtained by different methods, using plane grating, concave grating, interferometer, etc., and with the light taken from a definite portion of the arc.

C. P. B.

61. Spectrum of Iron Arc with Alternating Current. M. Hamy. (Comptes Rendus, 155. pp. 681-685, Oct. 7, 1912.)—In studying star spectra it is necessary to be able to produce a comparison spectrum which shall be determined exactly by the conditions of production. The condensed spark between iron electrodes, which has hitherto usually been employed, seldom yields, at two different times, two spectrograms exactly alike, even though all possible precautions are taken to secure the same conditions. In the present paper an alternating-current arc is described which gives very consistent results, is very easy to put in and out of action, and gives a large bright flame which affects photographic plates much more quickly than the condensed spark. At the end of the horizontal axle of an electric motor is fixed an iron rod (T), 6 mm. diam. and 100 mm. long, the rod being insulated from the axle, and at right angles to it. When the motor turns, the rod T becomes periodically vertical; it touches then the end of a second rod T', sensibly horizontal, and, in passing, makes this rod turn slightly about an axis A, which, in the author's arrangement, is about 100 mm. from the end of T' where contact takes place between the rods. A suitable counterpoise causes the rod T' to exert a constant pressure on the rod T at each contact. A stop can be adjusted so as to regulate the amount of depression of the end of T' at each contact. Experience shows that the pressure between T' and T should be very small, and that the depression of T' should not be more than about 0.1 mm. When the two bars are connected to the ends of a sector, through a suitable resistance, sparks are produced at each contact break, and these constitute the luminous comparison source. A monophase induction motor was used of 0.1 h.p., and its speed on no-load (as was the case in the arrangement used) was very con-

stant. The time for the rotor to make a complete turn is a little less than the period of the alternating current actuating the motor. Also the phase of the current is not always the same each time the bars T and T' come in contact. The appearance of the light ought thus to vary with the time; this was found to be the case. When the apparatus is working, flames start between the ends of the bars, develop, reach a maximum, diminish and disappear periodically. About 40 flames thus appear and disappear per minute. At a fixed voltage experience shows that the above arrangement gives remarkably constant results; practically identical spectrograms are obtained if the times of exposure are adjusted so as to obtain the same number of flames. If the voltage varies from that used (110 volts) to a neighbouring value V, Millochau has found that the time necessary to give a good photograph must be increased proportionately to the difference (110 - V). It is shown also how the apparatus may be used in the determination of radial velocities by Hartmann's method.

A. W.

62. Series Lines in Mercury Arc Spectrum. J. C. McLennan. (Roy. Soc., Proc. Ser. A. 87. pp. 256-288, Sept. 19, 1912.)—This paper constitutes the first of a series of studies on the distribution of series lines in the arc spectrum of mercury, as well as on the constitution of some of these lines, and on their resolution by magnetic fields. The best source of light was found to be a commercial Cooper Hewitt glass lamp with a side tube attached, which was closed by a thin plate of crystalline quartz. This gave the best-defined and the greatest number of spectral lines. Photographs were obtained showing well-defined lines ranging from $\lambda = 2150$ to $\lambda = 7000$. In the triplet series of lines the following members have been identified:—(1) Principal series: 1st group to $m = 18$, 2nd group to $m = 10$. (2) First subordinate series: 1st group to $m = 20$, 2nd group to $m = 17$, 8rd group to $m = 16$. (3) Second subordinate series: 1st group to $m = 20.5$, 2nd group to $m = 17.5$, 8rd group to $m = 14.5$. In the series of single lines the principal series has been identified to $m = 9$, the first subordinate to $m = 16$, and the second subordinate to $m = 12.5$. Illustrations are given of the "combination series" lines, calculated according to the scheme proposed by Ritz from elements of the triplet series and single-line series formulæ [see Abstract No. 1619 (1908)]. Diagrams are given of the positions of the lines in the different series, also photographs of the spectrum.

A. W.

63. Absorption Spectra of Aqueous Solutions of Neodymium and Praseodymium as Measured by Means of the Radio-micrometer. H. C. Jones and J. S. Guy. (Chem. News, 106. pp. 212-214, Nov. 1, and pp. 225-228, Nov. 8, 1912.)—A sensitive form of radio-micrometer is described in the form of a delicate moving-coil galvanometer, the coil of which consists of a single loop of thin copper wire with a blackened thermo-couple at one end. The elements forming the couple consist of alloys, one of which contains 90% Sn and 10% Bi, and the other 97% Sn and 3% Sb. When the coil, which with the couple and the attached mirror together weighs only 20 mgm., is suspended between the poles of a strong magnet, a very sensitive radiometer is obtained, which has been employed in the investigation of the absorption spectra of aqueous solutions of neodymium salts between $\lambda = 4000$ and $\lambda = 20,000$. From the radiometer readings, transmission curves have been plotted for the chloride, bromide, nitrate, sulphate, and acetate. According to these curves, the solutions in question exhibit sharply-defined absorption

maxima, and three of these, at $\lambda = 7800$, 7860 , and 8605 , have not been previously indicated in the experiments according to the photographic method. With regard to the influence of concentration on the absorption it is found that the bands are somewhat broader in the more concentrated solutions, but that the intensity of the bands increases with the dilution. This is interpreted in terms of the author's (Jones's) resonance theory. With praseodymium chloride and nitrate bands were located down in the infra-red as far as $2\ \mu$.
T. S. P.

64. *Ultra-red Emission Spectra.* H. Lehmann. (Ann. d. Physik, 89. 1. pp. 53-79, Sept. 5, 1912.)—Deals first with a source of error introduced into the results of wave-lengths obtained by the method of coincidence of different orders in grating spectra. Ritz showed [Abstract No. 2596 (1904)] that Lehmann's earlier measurements of ultra-red lines were in error by about $8\ \text{\AA}$. The author now shows that the errors were not due, as suggested by Ritz and by Hermann, to a certain error of the camera objective, but to the fact that the law for limiting rays is not fulfilled, as was first shown by Abbe. A method of avoiding the difficulty is suggested. Using the phospho-photographic method and a similar spectrographic arrangement to that used by Bergmann [Abstract No. 915 (1908)], with lens specially corrected for ultra-red rays, measurements were made on about 20 metals. Wave-length tables are given extending to about $\lambda 15000$ and photographs are reproduced.
A. W.

65. *Structure of Mercury Line, 5461 \AA.* L. Janicki. (Ann. d. Physik, 89. 2. pp. 489-448, Sept. 24, 1912. Communication from the Physikal-Techn. Reichsanstalt.)—The author finds the line five-fold with seven satellites—thus twelve components in all. He uses two crossed interference systems in order to have a means of distinguishing true lines from ghosts.
J. M.

66. *Electric and Magnetic Double Refraction.* W. Voigt. (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 5. pp. 577-598, 1912.)—This paper consists of:—(1) A generalisation of the Langevin theory of electric and magnetic double refraction (æolotropic molecules swung into line by the magnetic field, this alignment being opposed by heat). (2) A mathematical statement of the author's point of view—that the Zeeman-effect and the Langevin-effect are both operative: in some cases one will predominate, in some cases the other.
J. M.

67. *Theory of the Zeeman-effect in any Direction.* K. Försterling. (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 5. pp. 611-622, 1912.)—The author makes use of the analogy of an isotropic body in a magnetic field to a uniaxial, absorbing crystal, which rotates the plane of polarisation of the incident light. It follows from the theory that the damping of the motion of the electrons may be measured, even for those lines which have not yet been reversed.
J. M.

68. *Zeeman-effect.* C. Wali-Mohammad. (Ann. d. Physik, 89. 1. pp. 225-250, Sept. 5, 1912. Extract of Dissertation, Göttingen.)—The author has examined the zinc, cadmium, thallium, and bismuth lines and their satellites in fields from 5000 gauss down to 8000 gauss (in the case of very fine lines) with an echelon interferometer.
J. M.

69. *Solutions of Wave Equation*. A. Wiegrefe. (Ann. d. Physik, 89. 2. pp. 449-484, Sept. 24, 1912. Extract of Dissertation, Göttingen.)—Discusses mathematically the many-valued solutions of the wave equation $\Delta u + k^2 u = 0$ and their application in diffraction theory. E. H. B.

70. *Anomalous Dispersion in Sodium Vapour*. D. Roschdestwensky. (Ann. d. Physik, 89. 2. pp. 807-845, Sept. 24, 1912.)—A more complete account of the work dealt with in Abstract No. 1594 (1910).

71. *Colour-blindness and the Trichromatic Theory of Colour Vision*. IV. *Incomplete Colour-blindness*. W. Abney. (Roy. Soc., Proc. Ser. A. 87. pp. 826-880, Oct. 2, 1912.)—Explains a very simple test which gives a quantitative measure of the sensations in incomplete colour-blindness. [See also Abstract No. 709 (1912).] L. H. W.

72. *Spark Spectrum of Palladium*. P. E. Dhein. (Zeitschr. wiss. Phot. 11. pp. 817-848, Oct., 1912.)—Describes photographic measurements of wave-lengths of the spark lines of Pd, using the Rowland concave grating of the Physical Institute at Bonn. Tables are given of the lines from $\lambda 6784.622$ to $\lambda 1971.699$, the results being compared with those of Kayser, Exner and Haschek, and Morse and Lohse. Many new lines below $\lambda 2185$ are given. A. W.

73. *False Dissymmetries in the Zeeman-effect*. K. Körner. (Phys. Zeitschr. 18. pp. 797-808, Sept. 1, 1912.)—This paper deals with dissymmetries in the separation of lines by the magnetic field, arising from small errors in the adjustment of apparatus, pressure variations in the source of light, and other effects. J. M.

74. *Dispersion and Absorption of Mercury and Tin for the Visible and Ultra-violet Spectrum*. P. Erochin. (Ann. d. Physik, 89. 1. pp. 218-224, Sept. 5, 1912.)—A continuation of the work of W. Meier and V. Freedericksz. [See Abstract No. 819 (1910).] J. M.

75. *Quantitative Determination of Radium Emanation*. L. Flamm and H. Mache. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 227-248, Feb., 1912.)—The theoretical value of the saturation current, produced when emanation is distributed homogeneously between two parallel plates and the active deposit in equilibrium with the emanation is collected on the negatively charged plate only, has been investigated mathematically. The formulæ developed are tested and found in agreement with experiment. The saturation current for the α -rays from RaEm alone was found to be 2.67×10^5 e.s. units per curie, and that for emanation RaA and C 6.02×10^4 e.s. units. E. M.

76. *Vienna Standard Radium Preparations*. S. Meyer and V. F. Hess. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 608-681, April, 1912. Communication from the Inst. f. Radiumforschung.)—The standard preparations consist of the RaCl₂ prepared by Hönigschmidt in his determination of the atomic weight of Ra [Abstract No. 759 (1912)]. The present paper deals with (1) the heat evolution; (2) the ionisation due to the α -rays from a very thin film of the substance; (3) the ionisation due to the γ -rays, and (4) the amount of emanation in equilibrium with the material. The heat evolution of 1 gm. radium element in equilibrium with its products (emanation, RaA, VOL. XVI.—A.—1918.

B, and C) when all the α - and β -rays and 18% of the γ -rays were absorbed was found to be 182.26 gm. cal. per hour, or if all the γ -rays were absorbed 188 gm. cal. per hour. The calculated value based on the ordinary results for the initial velocities of expulsion of α -rays is very approximately the same as the experimental value. Different methods of determining the Ra-content of a preparation from its γ -ray ionisation were tested, and data are given for various dispositions, by means of which an ordinary preparation of radium can be standardised without the necessity of comparing it directly with a standardised preparation. The measurements of the current produced by 1 curie of RaEm in a cylindrical chamber without subsequent products gave the value 2.7×10^6 e.s. units, which is in good agreement with the result of Flamm and Mache [see preceding Abstract]. From the thorium content of the residues from which the Ra was extracted, and the fact that ionium is separated out with Th, it was deduced that the period of average life of ionium cannot exceed about 200,000 years. E. M.

77. *Comparison of Ionisations within Closed Vessels due to Röntgen and Gamma Rays.* A. S. Eve. (Phil. Mag. 24. pp. 482-486, Sept., 1912.)—If closed cylindrical vessels, made of various metals, equal in height and diameter and with walls about $\frac{1}{4}$ mm. thick, are exposed to the action of Röntgen rays and of the γ -rays from RaC respectively, then the following results obtained give a comparison of the ionising effects of the two types of rays :—

IONISATIONS.

Metal.	Atomic Weight.	Density.	Thickness.	X-Rays.	γ -Rays.
Lead	207	11.8	2.1 mm.	1.8	100
Copper	63.6	8.9	0.54	82	69
Zinc.....	65.4	7.1	0.44	111	69
Iron.....	55.9	7.8	0.55	100	68
Aluminium.....	27.1	2.6	0.64	126	58
Cardboard	—	—	—	125	49

The X-rays used came from a rather hard bulb, and their absorption coefficient in air was 0.0004 cm^{-1} . The results are at first sight very surprising, although they are not out of harmony with the view that the X- and γ -rays are similar in type. The explanation is based on the view that the X-rays ionise wholly by electrons projected with velocities of the same order as that of the cathode rays, and that the γ -rays also ionise by electrons projected with velocities of the same order as those of the β -rays from RaC. The corpuscles ejected by X-rays only traverse a distance of about 1 mm. in air, and originate chiefly in the air in the testing vessel. The decrease in ionisation with increasing density of material is due to increased absorption by the walls of the vessel. The electrons ejected by the γ -rays come chiefly from the walls of the vessel, and have an average path of about 2 m. Moreover, they are reflected to and fro by the walls of the vessel, in this way increasing the ionisation. The results for the variation of the ionisation with the vessels of different materials agree well with the results of Kovarik for multiple reflection of β -rays with the corresponding metals. [See Abstract No. 852 (1911).] E. M.

78. International Radium Standard. Mme. P. Curie. (Journ. de Physique, 2. Ser. 5. pp. 795-826, Oct., 1912.)—The paper contains an account of the method of comparing quantities of radium, particularly the γ -ray method. An ionisation chamber or γ -ray electroscope is recommended with lead walls at least 5 mm. thick. For correction, if the radium samples are not contained in the same vessels, μ for glass may be taken to be 0.1 cm.^{-1} , and for lead 0.5 cm.^{-1} . For glass vessels of $\frac{1}{4}$ mm. thickness the absorption of the γ -rays is only about 0.5%. Correction may be necessary in some cases for the absorption of the γ -rays by the material itself. It is necessary that the radium samples should have been sealed up at least a month previous to measurement so that the equilibrium amount of emanation may have been produced. The international radium standard is next described. This was prepared by Mme. Curie from the material used in 1907 for the determination of the atomic weight of Ra, the value found being 226.5. Part of this radium was purified from RaD, E, and F, and weighed in the form of anhydrous RaCl_2 , the weight being 0.02199 gm. (RaCl_2). This was placed in a glass tube of wall thickness 0.27 mm. and diam. 0.9 mm., and sealed off in Oct., 1911, with a piece of thin Pt-wire also sealed into the tube. The standard was compared with that prepared by Honigschmidt of Vienna (0.08117 gm. RaCl_2), and the two were found to have γ -ray activities corresponding to the weights to within 0.2%. The International Congress have therefore accepted Mme. Curie's radium preparation as standard to be placed in the Bureau international des Poids et Mesures. It is pointed out that as the radium was prepared from Joachimstal pitchblende, which contains little Th, no appreciable disturbance can arise from mesothorium, which is known to be always separated out chemically with Ra. E. M.

79. Charge carried by α - and β -Rays. J. Danysz and W. Duane. (Comptes Rendus, 155. pp. 500-508, Sept. 2, 1912.)—The experiments deal with the total charge carried by the α - and β -rays emitted from 1 curie RaEm in equilibrium with RaA, RaB, and RaC. As source a small bubble of emanation was used in a thin-walled spherical glass " α -ray bulb," the rest of which was filled with mercury. A definite beam of rays was taken and received by a Faraday cylinder connected to a quartz piézo-électrique. The apparatus was placed between the poles of an electromagnet. With no magnetic field the Faraday cylinder received charges due to α -, β -, and δ -rays. The latter were found to be cut off by a field of 60 gauss, the charge received being constant between 60 and 120 gauss and corresponding to the difference in the charges carried by the α - and β -rays. With increasing field up to 2500 gauss the β -rays were gradually cut off, and the positive charge received increased to a constant value from 2500 upwards to over 8000 gauss. This constant value was taken as a measure of the charge carried by the α -particles, and was found to be 90.8 e.s. units per curie, which is approximately 8 times the value 81.6 found by Rutherford and Geiger for RaC alone. The ratio of the charge carried by the β -rays to that of the α -rays was found to be 0.68, which, on the assumption that an α -particle carries a double positive charge, indicates 8.8 β -particles for the 8 α -particles (RaEm, A, and C). Corrections were necessary on account of a small fraction of very slow β -particles ($v < 1.8 \times 10^{10}$) which do not emerge from the bulb, and also for the reflection by the mercury. The authors conclude that there are at least 8, and perhaps 4, β -particles for the 8 α -particles. It is also concluded from the experiments that slow secondary rays of the nature of δ -rays are not excited in appreciable quantity by β -particles. E. M.

80. Demonstration of Range of α -Particles. K. Przibram. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 221-226, Feb., 1912.)—The paper deals with a simple apparatus for showing that α -particles have a limited range in air. A uniform fog of ammonium chloride is produced in a shallow chamber with parallel electrodes. α -particles are fired in from one end and an electric field applied. This electric field removes the fog in the region where the α -particles have produced ionisation, and the clear part of the tube is sharply divided from the foggy part. The length of the clear part is the range of the α -particles under consideration. The apparatus works specially well with polonium, owing to the absence of β -radiation with this product. E. M.

81. Variation of β -Radiation of Radium. F. v. Lerch. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 875-891, May, 1912.)—The author concludes from experiments that there is a radio-active product, designated RaX, between radium and radium emanation [see Abstract No. 80 (1911)]. A quantity of radium was subjected to various chemical and electrochemical operations, dissolved completely in acid, and the solution sealed up. The β -ray activity was then measured for several months. For the first 40 days the β -radiation increased to a practically constant value, due to the growth of RaEm, but over a period of several months subsequent to this it in some cases increased slightly and in others decreased, according to the various chemical operations previously undergone. These slow variations with time, amounting in some cases to over 10%, appear too large to be attributed to experimental error. The author suggests that the ratio of the radium to the new subsequent product RaX has been altered by the operations. When the ratio of RaX to Ra exceeds the equilibrium amount the β -radiation decays gradually after the equilibrium amount of emanation has been formed, and *vice versa*. E. M.

82. β -Particles Reflected by Sheets of Matter of Different Thicknesses. W. Wilson. (Roy. Soc., Proc. Ser. A. 87. pp. 100-108, Aug. 18, 1912.)—The author has investigated the nature of the β -rays reflected from various metal sheets when β -rays of UrX are incident on them. The UrX was obtained in a very pure form from 50 kg. of uranium nitrate. It is shown that the radiation can be split up into two parts: one with a very large coefficient of absorption, and the other with an absorption coefficient of the same order as that of the primary beam but decreasing with increasing thickness of the reflector. For very thick sheets the final absorption coefficients in Al of the more penetrating reflected radiation are found to be: Al, 88.7; Cu, 26.6; Pb, 20.2 cm.⁻¹. The coefficient of absorption of the easily absorbed part of the radiation reflected by Al is found to be 285 cm.⁻¹; and values of the same order are deduced for Cu and Pb. An expression is obtained for the variation of the amount of reflected radiation with thickness of reflector. E. M.

83. Reflection of β -Rays by Thin Metal Plates. W. B. Huff. (Phys. Rev. 85. pp. 194-202, Sept., 1912.)—The author used the β -rays from UrX and examined the quantity and absorption properties of the β -rays scattered so much as to emerge again on the incident side of various metal foils. It is shown that even the thinnest obtainable metal foils reflect a measurable amount of the incident β -radiation, the increase with thickness of foil being at first linear. With increasing thickness of reflector the reflected radiation was found to contain an increasing proportion of softer constituents, this being regarded as evidence of loss of speed due to passing through matter.

E. M.

84. *Number of β -Particles Emitted in the Transformation of Radium*, H. G. J. Moseley. (Roy. Soc., Proc. Ser. A. 87. pp. 230-255, Sept. 19, 1912.)—The recent researches of v. Baeyer, Hahn and Meitner [Abstract No. 819 (1912)] have shown that the β -radiation from a substance can usually be resolved by a magnetic field into a number of distinct groups of approximately homogeneous rays. It has been shown by Danysz [Abstract No. 825 (1912)] that more than 28 such groups are present in the radiation from RaB and RaC. It is, therefore, of interest to know the number of β -particles emitted per disintegrating atom emitted by these products. This number was determined by two methods. In the first method the particles were collected in a brass box thick enough to stop them all, and their number was deduced from the negative charge gained by the box. In the second method measurement was made of the positive charge gained by the active material (the α -particles being absorbed) as the result of the loss of β -particles. The number of disintegrating atoms was deduced from the α -particle measurements of Rutherford and Geiger. The results show that each atom of RaB and of RaC emits, on disintegrating, probably one β -particle, although measurement gives in either case as the average number 1.10. Each atom of RaE appears to emit less than one β -particle. The absorption of the β -radiation from the active deposit was studied, measurements being made both of the number of β -particles penetrating the absorbing material and of the ionisation they produce. From these data the ionising power of a β -particle in air, and its variation with the absorption coefficient of the radiation have been calculated; the number of ions produced per cm. of path being found to vary from 82 when $\lambda = 15 \text{ cm.}^{-1}$ of Al to about 160 when $\lambda = 100 \text{ cm.}^{-1}$. With the help of the data obtained by Geiger and Kovarik the numbers of β -particles emitted on disintegration by atoms of UrX, ThD, and AcD were estimated to be 1.08, and 1.4 respectively. The author deduces on certain assumptions, that each atom of RaC emits, on disintegrating, two γ -rays. The experiments also show that surfaces penetrated by β -rays emit a secondary radiation very similar to δ -rays. E. M.

85. *Half-value of the Radio-active Deposit Collected in the Open Air*. F. A. Harvey. (Phys. Rev. 85. pp. 120-127, Aug., 1912.)—It is shown from theoretical considerations that the half-value of a mixture of the active deposits from radium and thorium emanations must vary between very wide limits (45 mins. to several hours) if the percentage of Th active deposit varies from 0 per cent. to 50-70 per cent. Moreover it is shown that when atmospheric conditions are favourable, i.e. steady barometer and only slight changes in the wind, very good agreement is obtained between theory and experiment for the mixture of active deposits collected on a negatively-charged wire exposed in the open air. J. J. S.

86. *Radio-activity of Hot Springs of Yosina, Idu (Japan)*. D. Isitani. (Mathematico-Physical Soc., Tōkyō, Proc. 6. 18. pp. 275-279, July, 1912.)—The paper deals with experiments in continuation of those described in Abstracts Nos. 708, 1222 (1912). Two hot springs were investigated at temperature 47°C . The mean emanation-content was 78×10^{-13} curies per litre of water and 587×10^{-13} curies per litre of evolved gas (47°C). E. M.

87. *Progress in Radio-activity Research, 1908-1912*. O. Hahn. (Zeitschr. Elektrochem. 18. pp. 764-787, Sept. 1, 1912.)—A useful general survey.

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HEAT.

88. *Measurements of Expansion with Abbe-Fizeau Dilatometer.* W. Bein. (Kaiserl. Normal-Eichungs Kommission, Wiss. Abhandl. No. 8. pp. 8–52, 1912. Deutsch. Phys. Gesell., Verh. 14. 24. pp. 1097–1114, Dec. 80, 1912. Extract.) —Describes an elaborate series of measurements of the expansion of quartz, certain steels, brass, bronze, and copper at temperatures ranging from about 16° C. to 100° C. The formulæ of Benoît and Scheel for the expansion of quartz are verified, a very large number of measurements giving close agreement with the mean formula $Q_t = Q_0(1 + 715.25 \times 10^{-6}t + 0.808 \times 10^{-8}t^2)$.

A. W.

89. *Specific Heats of Liquids at Constant Pressure.* S. Lussana. (N. Cimento, 4. Ser. 6. pp. 207–282, Sept., 1912.)—Continuing his investigation of the subject [Abstract No. 658 (1909)] the author has determined the specific heats at constant pressure of mercury, methyl alcohol, acetone, amyl alcohol, and ether at different temperatures and pressures. It is concluded that, in general, the specific heat at constant pressure diminishes with increase of pressure, the results obtained being rather lower than those calculated from the isobars, and the diminution being approximately proportional to the increase of pressure. With increase of temperature, the reduction in the value of c_p with increase of pressure becomes less, in some cases changing into an increase; c_p increases with increase of temperature in the case of mercury only. The coefficient of variation of the specific heat with pressure for different temperatures, according to the equation $(c_0 - c_p)/c_0 p = \gamma$, is given in the following table:—

	Tempera- ture.	$\gamma \times 10^6$.		Tempera- ture.	$\gamma \times 10^6$.
Mercury	68.4°	— 1890	Acetone ...	12.5°	— 14728
Mercury	90.5	— 2581	Acetone ...	42.3	— 4665
Amyl alcohol ...	52.2	— 5189	Ether	26.1	— 14093
Amyl alcohol ...	77.4	+ 7288	Ether	6.7	— 14763
Methyl alcohol...	11.9	— 8831	Ether	9.4	— 14719
Methyl alcohol...	44.7	+ 82551	Ether	46.6	— 12908

A modification of the method of mixtures has been employed, and a full description of the apparatus, together with diagrams, is given. W. H. Si.

90. *The Melting-point of Cupric Oxide.* R. E. Slade and F. D. Farrow. (Zeitschr. Elektrochem. 18. pp. 817–818, Sept. 15, 1912.)—L. Wöhler stated in 1906 [see Abstract No. 146 (1907)] that cupric oxide heated at atmospheric pressure in a strong current of oxygen (Pt crucible in electric furnace) melted at 1055° C., and that the cooling curve showed a bend at 1064°; he did not analyse the fused product. The authors repeated these experiments, also by the method of G. K. Burgess, and found that the melting-point of CuO varied between 1096° and 1150°, because decomposition took place; copper itself gave in hydrogen after Burgess' method the melting-point 1078° (instead of 1068°). The melting-point of CuO seems to lie above 1148°; for it does not melt at that temperature under an oxygen pressure of 2.5 atmos. but

begins to decompose then. It begins to liberate oxygen, however, at 1090° already when heated in an oxygen atmosphere at ordinary pressure; the liquid contains more than 50 per cent. of Cu_2O and solidifies completely at 1064° , which is Wöhler's point.

H. B.

91. *Realisation of the Thomson-van der Waals p - T - v -surface.* J. Meyer. (Zeitschr. Elektrochem. 18. pp. 709-710, Aug. 15, 1912. Paper read before the Deutsche Bunsen-Gesell., Heidelberg, May, 1912.)—The author has determined the temperatures to which different liquids can be heated under a pressure of $p=0$ before vapour formation occurs, with the following results:—

Sub-stance.	T' found.	T' calc..
Ethyl ether	$278 + 115^{\circ}$	$278 + 128^{\circ}$
Methyl ethyl ether	$278 + 58$	$278 + 64$
Isopropyl ethane	$278 + 95$	$278 + 97$
Benzene	$278 + 168$	$278 + 194$
Ethyl alcohol	$278 + 155$	$278 + 155$

Van der Waals has shown that the value of T' is equal to $(27/82)T''$, where T'' is the critical temperature. The values in the third column of the table have been calculated from this relationship. The author holds that the above experimental material confirms the existence of a minimum for the Thomson-van der Waals surface. It may be mentioned that in the case of water the author found that the temperature could be raised to 220° without formation of vapour occurring, the water being under a pressure of $p=0$.

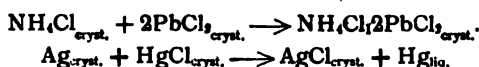
A. F.

92. *Researches on Specific Heats.* I. J. N. Brönsted. (Zeitschr. Elektrochem. 18. pp. 714-717, Aug. 15, 1912.)—The author has determined the specific heats of a number of substances, the values found being given in the following table:—

Substance.	Specific Heat.	Atomic or Molecular Weight.	Atomic or Molecular Heat.
Tin (white)	0.05882	119.06	6.408
Tin (grey)	0.04962	119.06	5.908
Potassium hydrogen tartrate	0.2814	118.01	48.50
Potassium hydrogen racemate	0.2848	118.01	44.14
Aragonite	0.1899	100.12	19.01
Iceland spar	0.1887	100.12	18.89
Thallous picrate (yellow)	0.184	482.1	57.9
Thallous picrate (red)	0.187	482.1	59.2
Ammonium chloride	0.8594	58.50	19.28
Lead chloride	0.06565	278.0	18.25
Ammonium lead chloride	0.0866	609.5	52.78
Silver chloride	0.08775	143.85	12.58
Mercuric chloride	0.05019	255.76	11.88
Silver	0.05585	107.89	5.972
Mercury	0.08825	200.8	6.660

The results obtained by the author are in harmony with the van't Hoff-Thomson rule that when a transition point is present the form stable at

higher temperatures has the greater specific heat ; but in the case of the two forms of tin the values are not in harmony with the Richarz rule that the substance with the higher specific heat has the smaller specific gravity. This is contrary to a result found by Wigand [Abstract No. 1081 (1907)]. From the results obtained in the case of the last seven substances in the above table it is possible to calculate the temperature coefficient of the heats of reaction in the two cases—



For the former reaction we obtain $A = 2780$, $dA/dT = +8.3$; $U = +850$, $dU/dT = +8.0$. For the latter reaction, $A = +1050$, $dA/dT = +8.0$; $U = -1800$, $dU/dT = -1.4$.
A. F.

93. *The Nitrogen Thermometer Scale from 800° to 680°.* A. L. Day and R. B. Sosman. (Amer. Journ. Sci. 88. pp. 517-538, June, 1912. Ann. d. Physik, 88. 4. pp. 849-869, July 12, 1912.)—In the recent investigation of the fundamental high-temperature scale with the gas thermometer attention was chiefly directed to the temperature region above 1000°. Determinations of the lower temperatures have been made in the Reichsanstalt [see Abstracts Nos. 2008 (1900), 1979 (1908), 400 (1910)]. The authors have repeated their measurements with more elaborate precautions to secure a uniform temperature about the bulb—the one factor in the measurements about which some uncertainty remained. The new gas-thermometer temperatures are collected in the following table, expressed in terms of N expanding at constant volume from an initial pressure of 76 cm., and in terms of the thermodynamic scale. These values replace the corresponding temperatures published in the authors' previous papers :—

Point.	Temperature.		Notes.
	Const. Vol. $p_0 = 1$ atmo.	Thermo- dynamic.	
Benzophenone (Kahlbaum) boiling-point at 76 cm.	805.85	805.9	Transferred by platinum- rhodium and copper- constantan thermo- elements.
Cadmium, melting-point ...	820.8	820.9	Interpolated.
Zinc, melting-point	419.8	419.4	Transferred by thermo- elements.
Sulphur, boiling - point at 76 cm.	444.40	444.55	Direct.
Antimony (Kahlbaum), melting-point	629.8	630.0	Transferred by thermo- elements.
Aluminium, melting-point	658.5	658.7	Interpolated.

A comparative table is added showing in terms of the same (thermo-
dynamic) scale a comparison of the results with those obtained by Holborn
and Henning in the latest work published from the Reichsanstalt.

COMPARATIVE TABLE.—THERMODYNAMIC SCALE.

Point.	Holborn and Henning, 1911.	Day and Sosman, 1912.
Benzophenone	805.9	805.9
Cadmium	820.9	820.9
Zinc	419.4	419.5
Sulphur	444.5 ₁	444.5 ₂
Antimony	Holborn and Day. 680.6	680.0

J. J. S.

94. *Spheroidal State*. C. W. Batdorf. (Phys. Rev. 85. pp. 217-226, Sept., 1912.)—Measured by means of a Pt and Pt-Rh thermo-couple, the temperature of water in the spheroidal state is found to vary between 97.5° and 91.76° C., gradually falling as the globule of water becomes smaller from evaporation. Occasionally the temperature remains fairly constant for a minute or more, with an approximate equilibrium temperature of 96.18°. The temperature of the plate, at which, as it cools, the spheroidal drop touches it, varies with the nature of the plate, depending on its conductivity. It also varies with the size of the drop, in the case of an iron plate being 260° for a drop of 2 gm. and 280° for a drop of 0.5 gm. The star forms and other figures produced by water, mercury, liquid air, ether, etc., in the spheroidal state have been fully studied, and photographs of many of these are reproduced.

W. H. St.

95. *The Melting of Ice*. E. E. Somermeier. (Phys. Rev. 85. pp. 126-185, Aug., 1912.)—It was found that dry ice sticks and crystals inside a test-tube which is immersed in a mixture of ice and water, will melt at the same time that other ice crystals are freezing out of the mixture surrounding the tube, the crystals inside the tube and the mixture surrounding it both being at atmospheric pressure and the temperature of the room being 0° C. or below. The author can offer no satisfactory explanation of the results. Experimental efforts to explain them are negative. Various suggested possible explanations lack experimental proof.

J. J. S.

96. *The True Second Law of Thermodynamics*. J. T. Wainwright. (Engineer, 118. p. 658, June 21, and 114. p. 90, July 26, 1912.)

97. *Kirchhoff's Law*. F. Richarz. (Zeitschr. wiss. Phot. 11. pp. 254-260, Aug., 1912.)—A theoretical discussion and demonstration of Kirchhoff's law.

A. W.

98. *Boltzmann Proof of Second Law*. P. Hertz. (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 5. pp. 566-576, 1912.)—Statistical treatment for the second law of thermodynamics. [See Abstracts Nos. 815 (1911) and 521 (1912).]

E. H. B.

99. *Constant in Stefan-Boltzmann's Law*. S. Valentiner. (Ann. d. Physik, 89. 2. pp. 490-492, Sept. 24, 1912.)—Comments on previous work with a bibliography. [See Abstracts Nos. 1229, 1230, and 1231 (1912).]

E. H. B.

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SOUND.

100. *Duration of Sound of Alloys as a Function of Temperature.* F. Robin. (Rev. de Métallurgie, 9. pp. 618-687, Aug., 1912.)—The duration of the sounds of suspended bars of metal varies with temperature, and the nature of this variation has here been investigated and shown as graphs in sixteen figures dealing with pure metals, bronzes, brasses, and German silvers. The pure metals are of feeble sonority, whereas certain alloys show a marked improvement due to the introduction of a very small quantity of some constituent. Many of the curves show a decrease of duration of sound with rise of temperature up to about 800°C. , and then a sudden increase to about 850° with a second falling-off for higher temperatures. E. H. B.

101. *Time Needed for Perception of Pitch.* G. Leimbach. (Ann. d. Physik, 89. 1. pp. 251-254, Sept. 5, 1912.)—Puts forward a proposed method, by means of telephones, contacts, and a pendulum, for the determination of the time needed for the appreciation of the pitch of a musical sound. The minimum time found by O. Abraham and L. J. Brühl in 1898 was 0.00068 sec for the four-times accented *g*, being two of its complete vibrations. E. H. B.

102. *Sound Vibration Curves.* D. C. Miller. (Engineering, 94. p. 550, Oct. 12, 1912. Paper read before the British Assoc. at Dundee.)—For photographic registration of sound vibration curves a horn is used to take up the vibrations, a diaphragm of glass, 0.08 mm. in thickness, and a fine thread of Pt (or quartz) attached to the membrane. This thread was kept stretched by a load of 5 gm., and led to a steel spindle, 0.01 mm. diam. and a mirror—these two together did not exceed 2 mgm. in mass. The apparatus responded to 12,000 complete periods per sec. The room in which the experiments were made was padded with $1\frac{1}{4}$ in. of felt. The vibration photographs of a tuning-fork (256) were almost perfect sine curves, a stopped organ-pipe gave a clear curve without any overtone, an open pipe gave one overtone. The vibrating string of a violin showed the ripples or steps of the overtones described by Helmholtz, and vowels and words spoken produced very peculiar curves. The violin gave eleven overtones, the clarinet hundreds of overtones. When some of these curves were analysed with Henrici's analyser for Fourier series, and the curves then reproduced by a synthetiser, it was found that the horn exaggerated certain waves to four times their amplitude and reduced others. E. H. B.

103. *Reed Pipes with Conical Portions.* E. Hoppe. (Ann. d. Physik, 89. 8. pp. 677-692, Oct. 15, 1912.)—Recounts a series of experiments on reed organ-pipes with a conical portion at the end. Four pipes were dealt with, three having brass reeds and one a steel reed. The experiments lead to the practical conclusion that the pitch of the pipe may be controlled not only by the tuning wire which shortens the reed, but also by the shading (or contraction) of the opening. Further, the conical portion in general plays only the part of the funnel in a megaphone. So soon, however, as the length of the conical part is sufficient to make its own tone correspond to any overtone of the fundamental, then it both increases the intensity and affects the quality of the pipe. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

104. *Drop Method for Electronic Charge.* A. C. Lunn. (Phys. Rev. 35. pp. 227-230, Sept., 1912.)—Points out a correction theoretically needed in the above method for determining the elementary charge. But the numerical calculation shows that in Millikan's determination this correction would be of the order only one part in ten thousand. E. H. B.

105. *Electrified Particle in Magnetic Field.* R. Birkeland. (Archives des Sciences, 84. pp. 105-119, Aug., 1912.)—A defence of a previous paper by the author against an attack on it by C. Störmer. [See Abstract No. 896 (1912).] E. H. B.

106. *Contact Difference of Potential.* A. Anderson and H. N. Morrison. (Phil. Mag. 24. pp. 302-307, Aug., 1912.)—The contact p.d. of two metals depends on the state of the surface of the metals. The effect of making the surface of a metal bright and clean is to render it more electro-positive to other metals, and the magnitude of the effect is different for different metals. It was found that the contact p.d. in volts relative to a plate of uncleaned copper was in the case of freshly cleaned zinc 0.826 volt, and for uncleaned zinc 0.466 volt. Similarly the number for freshly cleaned Cu towards uncleaned Cu was 0.060 volt. The effect is a surface effect and experiments were made to test the action of ultra-violet light on the contact p.d. when copper and zinc were examined, the latter being exposed to ultra-violet light. It was found that with a powerful source of ultra-violet light there is a decided electro-negative increase which disappears slowly when the source is removed. The explanation on the electron theory of the results obtained is discussed in the paper. J. J. S.

107. *Residual Charge of Leyden Jar.* G. Brentano. (Phys. Zeitschr. 18. pp. 855-858, Sept. 15, 1912.)—A Leyden jar is charged with electricity of one sign, then discharged and afterwards charged with electricity of the opposite sign. It is then discharged, and its electrical behaviour observed by means of an electrometer. It is found that the first residual charge reappears after the second, even though the jar may have been charged in the second case to a higher potential than at first. Mechanical vibration has no effect on the reproduction of the residual charges. T. P. B.

108. *Behaviour of Ionised Liquid Dielectrics during the Passage of Electric Currents.* H. J. van der Bijl. (Ann. d. Physik, 39. 1. pp. 170-212, Sept. 5, 1912. Abstract of Dissertation, Leipzig.)—The theory of electrical conductivity in dense gases can be applied to ionised liquid dielectrics. In particular the recombination of ions in liquid dielectrics proceeds according to Thomson's formula $dn/dt = -an^2$. The coefficient of recombination of ions in hexane, carbon tetrachloride and carbon disulphide were determined independently of the influence of diffusion. Langevin's formula was verified experimentally and used to determine the sums of the mobilities of the positive and negative ions. Their diffusion-constants in hexane were determined by a new direct

method. The charges of the ions in hexane were determined and were found to be the same for positive and negative ions and in each case to be equal to the charge of the hydrogen atom in electrolysis. T. M. L.

109. *Diurnal Variations of the Electric Waves occurring in Nature and Propagation of Electric Waves round the Bend of the Earth.* W. H. Eccles. (Roy. Soc., Proc. Ser. A. 87. pp. 79-99, Aug. 18, 1912.)—Natural electric waves are probably the result of discharges between masses of electrified air, or between such masses and the earth. Until recently it was not known whether the discharges at any station were taking place at distances of hundreds of miles or thousands of miles, but it is now certain that, for England, the distances are of the order of thousands of miles. The number of natural wave-trains or "strays" received varies from hour to hour, and in England the variations are most pronounced during the summer months, principally on account of the frequency of local lightning storms during these months. In the winter, the number and intensity of the strays are relatively regular. The author gives typical 24-hour records, made by the aid of a telephone. The records are made by pencil-marks on paper ruled in convenient units of time so that the height of the mark represents the intensity, and the shape of the mark the duration and character, of the sound. These records can be made to yield approximately accurate quantitative results by plotting rough estimates of the time integral of the intensity of the strays. One method of doing this is to count the number of marks in each 2-minutes' interval, and using these numbers as ordinates corresponding to the mid times. The theoretically more perfect method is to pass the detector currents through a sensitive galvanometer possessing a heavy moving system.

The author then turns to a mathematical discussion on the ionisation of the higher and rarer regions of the atmosphere. H. H. H.

DISCHARGE AND OSCILLATIONS.

110. *Phosphorus-content of Phosphorus Fog Particles.* K. Przibram. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 247-254, Feb., 1912.)—The charge of the particles in a phosphorus fog has been found to be 6×10^{-10} e.s. unit [see Abstract No. 1471 (1910)]. If this is correct, then to account for it we must assume that the density is 1.4 and that the phosphorus contained is in the form of phosphoric acid [see Abstract No. 788 (1912)]. It is now found that, under the given conditions, in a phosphorus fog, with each electrostatic unit there is on the average 1.48×10^{-6} gm. phosphorus. In each cm.³ of phosphorus air there are in the mean over 1.54×10^{-3} e.s. units of one sign. It appears that both signs are about equally represented. If the average charge is 9×10^{-10} e.s. unit there are 1.7×10^7 particles of one sign in each cm.³. The phosphorus-content of a particle is in the mean 1.8×10^{-16} gm.

A. E. G.

111. *Spontaneous E.M.F. in Cells of Alkali Metals.* J. W. Woodrow. (Phys. Rev. 85. pp. 208-209, Sept., 1912. Electrician, 70. pp. 282-288, Nov. 15, 1912. Abstract.)—An investigation of the negative charge spontaneously developed by the alkali metal in photo-electric cells, leads to the conclusion that positively-charged particles are given off by the metals in a high vacuum, the emission being sufficient at high temperatures to counter-balance the ordinary photo-electric effect in the light. Apparently only a very small proportion of the atoms in the surface layer of the alkali metal are

active, the number increasing with the temperature. Experiments have been made with caesium, potassium, and an alloy of Na and K in quantities proportional to their atomic weights, a max. potential of 2.2 volts being obtained at about 75° C., and a minimum of 0.78 volt at 25° C. At low temperatures, the current i rises with the temperature up to 0° C., falling again as the temperature rises to 80°. Above 80° it increases with the temperature according to the equation $i = aT^{1/2}e^{-b/T}$, where a and b are constants, and T the absolute temperature. If an electrode of Al is used, the surface of the Na-K alloy becomes coated with a white film, even with the best possible vacuum, unless the cell is exposed to light while short-circuited, but whether this is due to gases contained in the Al electrode or to some action between the alkali vapour and this electrode has not been determined. No film occurs with a Pt electrode.

W. H. ST.

112. *Positive Rays*. W. WIEN. (Ann. d. Physik, 89. 8. pp. 519-544, Oct. 15, 1912.)—In a former paper [see Abstract No. 961 (1910)] results were described which show that in oxygen canal rays there is a decrease in the ratio of negative to positive ions when the observation tube is cooled, and it was thought probable that this behaviour of the negative atom is to be attributed to the presence of Hg vapour. It was, however, not proved that other vapours which might have a similar effect were not simultaneously removed. One object of the present experiments is to prove, if possible, a direct action of the Hg vapour. By a special arrangement of the cooling tubes it is shown that on account of the presence of Hg vapour the oxygen canal rays do contain an excess of negative ions. The other problems considered are: the passage of oxygen canal rays through CO₂, and determination of the mean free path of the canal rays. The latter is dealt with in sections, viz. Theory of the recharging phenomena in canal rays. Experimental arrangements for measuring the free paths. Observations. Control of the measurements of L_1 by the direct determination of L_2 (L_1 being the mean free path of the charged atom, L_2 that of the uncharged). Comparison of the number of collisions with the quantity of light of line H β emitted by canal rays.

A. E. G.

113. *Generation of Light in the Glow Discharge and Canal Rays*. L. VEGARD. (Ann. d. Physik, 89. 1. pp. 111-169, Sept. 5, 1912.)—By Stark's discovery that the canal-ray particles themselves emit light, a new means of studying light-excitation is obtained. The Doppler-effect enables the displaced light to be observed, and by variations in the conditions of discharge and collision the conditions of excitation can be altered in a known manner. The views of various observers are stated, and since there appear to be no satisfactory results as to the laws and variations respecting the series spectrum of hydrogen, the intensity distribution of that spectrum under different conditions of excitation is made the principal object of the present experiments. The question is dealt with as follows:—Comparison of the intensity distribution of the hydrogen series spectrum for negative glow and canal rays with the same discharge conditions. Proof and measurement of a possible displacement in the distribution of the total intensity by alteration of the discharge potential. Separation of the potential and pressure effects in total observed displacement. Explanation of the pressure and potential effects by analysis of the "moving" and "rest" intensity. Dependence of the intensity of the light in the "rest" and "moving" intensity on the velocity of the rays and the pressure of the gas into which the rays enter.

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It is found that the intensity distribution of "rest" intensity is invariable within the limits of the experiments. The intensity distribution of the "moving" intensity shows no marked alteration with the potential so long as the pressure in the observation space remains constant. It is also usually different from that of the "rest." The ratio of "moving" to "rest" intensity of a line changes greatly with the potential, the ratio always decreasing with increasing potential. It is also altered by a change of pressure in the observation space. The "rest" intensity becomes relatively smaller as the pressure is lowered. The intensity distribution of the "moving" spectrum shows a very marked pressure effect, so that the difference between the distribution in the "moving" and "rest" spectrum is decreased by a lowering of the pressure. The intensity distribution of the "rest" spectrum is identical with that of the negative glow, a fact which makes it all the more probable that the excitation process is the same in both cases. In an appendix the influence of the charged condition on the properties of the emitted light is considered.

A. E. G.

114. *Oscillations in Poulsen Arc Circuit.* K. Ort. (Jahrbuch d. Drahtlosen Telegraphie, 6. pp. 119-182, Sept., 1912.)—The author uses the Braun tube for the investigation of oscillations generated by the Poulsen arc. He obtains Lissajous figures on the screen of the tube by deflecting the kathode beam, in a direction perpendicular to that due to the oscillation under investigation, by means of a pure sine oscillation which is obtained from a subsidiary circuit of large self-induction and small capacity in tune with and very loosely coupled with the arc circuit. The sine oscillation deflects the beam electrostatically. Curves of the oscillations deduced from the figures are given. They agree with the observations of others and with theory.

T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

115. *Electric Conductivity of Bismuth-Thallium Alloys.* A. E. Whitford. (Phys. Rev. 85. pp. 144-147, Aug., 1912.)—The investigation described was undertaken to study further the extent to which compounds, as determined from the melting-point curve, influence the trend of other physical properties of alloys. The specimens were cast in glass tubing in an atmosphere of hydrogen, and care was taken to ensure a homogeneous mixture in the preparation of the alloy. The results are given in a table showing the electrical conductivity of each specimen and its method of preparation. From the graphical summary it is seen (as was to be expected) that a discontinuity occurs on the conductivity curve at 68 per cent. Bi, corresponding to Bi_2Tl_3 , but an ordinary cusp is not formed at this point. At the other Bi-Tl compound (10.9 % Bi) no discontinuity was detected. The characteristics of this curve agree with those of the magnetic susceptibility curve of the Bi-Tl series.

J. J. S.

116. *Variation of Electrical Resistance of Oxides with Temperature.* A. A. Somerville. (Metallurgical and Chem. Engin. 10. pp. 422-428, July, 1912.)—Resistance as a function of the temperature of various oxides was measured. At ordinary temperatures the oxides were as a rule non-conductors. As the temperature rises the resistance decreases, and at 1000° C. most of them may be classed as conductors. The oxide in the form of a powder was placed in a porcelain or quartz tube about 1 cm. in diam. and 10 cm. in length. Nickel

rods were made to fit into the ends of the tube against the ends of the column of oxide which was about 5 cm. long. Pressure was put on the ends of the nickel rods to produce constant contact on the oxide. The oxide was heated in its containing tube in a tubular resistance furnace, and temperature was measured by a Pt-resistance thermometer. There is a marked similarity in the way in which the resistance of the various oxides changes with temperature. The materials used, with the temperature at which each has a resistance of 10,000,000 ohms are as follows:—ZnO, 898° C.; Fe₂O₃, 252°; CuO, 290° (first heating); CuO, 895° (after once melted); Cu₂O, 187° (first heating). Cu₂O, after first heating, measures 90,000 ohms at 0° C.; MgO, 545°; MnO₂, 120°. The resistance in ohms of these substances at 1100° C. is as follows:—MgO, 1200; Cu₂O—changed to Cu + CuO at about 900° C.; Cu₂O, 18—(after first heating); CuO, 85 at 1084° (melting-point); CuO, 1600 (after once melted); MnO₂, 70; ZnO, 72; Fe₂O₃, 80; Al₂O₃, ? (infinite). J. J. S.

117. *Effect of Temperature and Transverse Magnetisation on the Resistance of Graphite.* D. E. Roberts. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 148–155, Sept. 8, 1912.)—About twenty specimens of Ceylon graphite were investigated, which all gave variations of resistance of a high order at ordinary temperature (18°). The increase of resistance in a field of 20 kilogauss varied between 800 and 500 % of the resistance in zero field, no doubt owing to impurities and the difficulty of obtaining specimens of graphite of definite crystalline structure. The isothermal curves showing effect of transverse magnetisation can be represented by the formula: $R'/R_0 = R/R_0 + AH^n$, where R_0 is resistance at 0° for $H = 0$, $R =$ resistance at θ° for $H = 0$, $R' =$ resistance at θ° in transverse field H , and A and n are constants. From the above equation taking logarithms—

$$\log (R' - R)/R_0 = \log A + n \log H,$$

which can be represented by a straight line, the co-ordinates being $\log (R' - R)/R_0$ and $\log H$. The value of n is the same for 5 specimens specially examined. Experiments were made at -179° , 0° , $+18^\circ$, $+95^\circ$, and $+179^\circ$, the field varying from 0 to 40 kilogauss. The increase of resistance is much greater at low temperatures. At the temperature of liquid air the increase is 9800 % for a field of 88.8 kilogauss, the increase at 18° being 1250 %. J. J. S.

118. *Polarisation E.M.F. of a Mixture of Clay, Felspar, and Quartz.* A. A. Somerville. (Electrical World, 60. pp. 408–405, Aug. 24, 1912.)—Investigations were made of the electrical resistance and temperature coefficient of oxides and rare earths in the form of powders. It was found that the Nernst filament and Pt give the largest thermal e.m.f. of any materials known. A mixture of clay, felspar, and quartz acts as a sort of storage battery or condenser, and gives out a current with a definite e.m.f. for some hours after it has been charged. The e.m.f. depends upon temperature, time of charging, and the voltage and electrodes used. The mixtures used varied in composition; the clay was composed of equal parts of English ball clay and English china clay, and these were mixed with powdered felspar and quartz. At ordinary temperatures the mixtures were almost complete insulators, but between 400° and 700° C. the resistance decreases rapidly, and then at 1000° the rate of change is much less. The specimens were suspended in a horizontal tubular specially-wound furnace. The temperature was measured

by a resistance thermometer. At about 1000°C . it was found that in that arm of the Wheatstone bridge in which the specimen was placed (in measuring the resistance) there was a polarisation e.m.f. This was examined and was found to be a function not only of the electrolyte but also of the electrodes as well, and the rate of discharge depends on the size of the electrodes. The voltage obtained is a function of the charging e.m.f. The counter-e.m.f. is also dependent upon the temperature, and decreases as the latter increases.

J. J. S.

119. Resistance between Metal and Crystal at Flat Surfaces of Separation. F. Streintz. (Phys. Zeitschr. 18. pp. 678-677, July 15, 1912.)—Silver litharge was examined in small cylinders of 4.2 mm. height with diam. of flat surface 9.8 mm. The dependence of the apparent resistance upon the current strength and the pressure between smooth polished silver plates was extraordinarily great. Also with long-continued application this resistance was in a high degree dependent on the respectively applied current strengths. If the transition resistance, as the author conjectured, were due to layers of gas which were held on the surfaces of the crystals, it would appear not to be impossible to free the crystals from this. In liquid air the conductivity rapidly rises so that over 200° its resistance is only a small fraction of an ohm. Silver glance possesses also the peculiarity that when placed close to a metal it gives off sulphur and causes the formation of a new sulphide. Between gold leaves its position is indicated after a few days by the tarnishing of the metal even at ordinary temperatures. At higher temperatures a brown-red stain is produced due to gold sulphide. An atmosphere is formed close to the surface of the crystals, and the transition resistance seems to be caused by the layer of gas. This was confirmed by further experiments. Silver glance is not singular in its behaviour: other similar crystals gave similar results. In one case the effect of heating the surface was to reduce the resistance to one-tenth of its former value by abolishing the layer of gas. For this purpose electric ovens and sometimes a spirit lamp were used.

J. J. S.

120. Relations between the Electric and Magnetic Fields of a System of Parallel Conductors of Infinite Length. O. Colard. (Assoc. Ing. ÉL. Liège, Bull. 12. pp. 885-889, July, 1912.)—The author assumes that the resistivity of the conductors is zero. The magnetic force at a point at a distance r from an infinite straight filament of current of magnitude i is $2i/r$. The direction of the force is at right angles to the radius r in a plane at right angles to the filament. If the filament instead of carrying the current i is charged with q units of electricity per unit length, the electric force is $2q/r$, the direction of the force being along r . The author proves that if L be the self-inductance, C the capacity, etc., of the various wires $(\Sigma L^2)/(\Sigma q^2/C) = \lambda/\mu$, where λ is the dielectric coefficient, and μ the permeability of the medium. For two parallel wires $CL = \lambda\mu = 1/v^2$, where v is the velocity of light.

A. R.

121. Measurement of Mutual Induction. F. Kock. (Jahrbuch d. Drahtlosen Telegraphie, 6. pp. 118-119, Sept., 1912.)—The author determines the coefficient of mutual induction between two coils as follows:—A condenser circuit, containing one coil and a thermo-element, is excited by undamped oscillations of low or high frequency. The second coil is closed through a thermo-element, and the effective current strengths, I_1I_2 , in the two circuits are obtained. Then $I_1I_2 = \sqrt{(r_1^2 + p^2L_1^2)}/pM$, where $p = 2\pi n$, r_1 and L_1 are

respectively the alternating-current resistance and the self-induction of the second coil; M is the coefficient of mutual induction. Results by this method are shown to agree well with those obtained by other methods.

T. P. B.

122. *Dielectric Hysteresis*. **W. M. Thornton**. (Phys. Soc., Proc. 24, pp. 801-815; Discussion, pp. 815-816, Aug., 1912.)—The polarisation in a solid insulator in a steady and uniform field of electric force differs from other polarisation, mechanical or magnetic, in the manner in which the final value is reached. After the initial displacement at the velocity of electromagnetic waves in a medium which occurs on starting the field there is a slow increase of polarisation maintained at a uniform rate for several hours, and the final value at which equilibrium is reached is independent of the intensity of the external field [see Abstract No. 612 (1910)]. The polarisation decays, on stopping the latter, at the same rate as that at which it was established, and in the end entirely disappears. The effect (common to all dielectrics) is an example of "elastic afterworking" unique in range and duration. There is a well-marked period of transition between the first polarisation and the complete establishment of the second stage, and in this any electric hysteresis loss must arise, for in the first stage the displacement is elastic, and in the second is unaffected by the external field. In the paper the author endeavours by the examination of wave-forms of alternating current in condensers built up of flat sheets of dielectric, to find the range and magnitude of polarisation under simple harmonic electric stress, at a frequency low enough to retain the features of hysteresis observed in steady fields, and high enough to be examined by the oscillograph in the usual way. The effect is observed in practice by the accumulation of charge on the conductors of direct-current cables left insulated after use, giving rise to voltages sometimes greatly in excess of the working pressure. It is observed in high-voltage alternating-current systems by heating of the insulation of cables through the conductor of which the only current passing is that required to supply the dielectric polarisation. The condensers used in the experiments described were made up with flat sheets of dielectric overlapping intermediate sheets of tin-foil. The substances used were glass, ebonite, india-rubber, gutta-percha, paraffined paper, Empire cloth, Empire paper, press-spahn, and a paper impregnated with a resin-oil compound used in the manufacture of high-tension paper-insulated cables. The frequency was constant throughout at 30.5 complete periods per second. From the dielectric hysteresis loops the nature of the change of polarisation which gives rise to the absorption of energy was investigated. Current and voltage wave-forms were oscillographically recorded. Certain substances, like glass or gutta-percha, were found to show a marked triple-frequency harmonic in the current wave out of phase with the fundamental. Most of these have a low power factor; others, like press-spahn, show little distortion, but have a high power factor. The loops for the former have straight parallel sides and a true hysteresis retardation as the voltage begins to fall; the latter have lens-shaped loops corresponding to a purely viscous retardation. Every variety of transition is observed between these extreme types. The cause of the former is probably inter-attraction between the induced molecular charges reaching a maximum at the highest voltage; that of the latter is a resistance to their movement through the substance during the establishment of the usual polarisation, the retardation being at a maximum when the rate of change of the voltage is greatest—i.e. in passing through zero. The dielectric constants of substances

with lenticular loops are more affected by change of frequency than the straight-sided type, that of press-spahn changing from 4.8 at 78 \sim , to 6.8 at 15 \sim per sec. Ebonite and paraffined paper change by less than 1 per cent. during the same range. For the same substances change of voltage gradient, short of breakdown voltage, has little or no influence on dielectric constant at this frequency. Power factor appears to increase with frequency within the range determined. J. J. S.

123. *Recent Improvements in the String Electrometer.* C. W. Lutz. (Phys. Zeitschr. 18. pp. 954-962, Oct. 15, 1912.)—Illustrated.

ALTERNATING CURRENTS AND MAGNETISM.

124. *Action of an Intermittent Contact in an Alternating-current Circuit containing Capacity.* A. Lampa. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 899-940, May, 1912.)—It was found that when a circuit containing a glow-lamp and a condenser in series is connected to a supply of alternating current through a contact consisting of a brass brush pressing lightly on a rotating copper disc, the effective current is greater than when connection is through a fixed contact. The effect is due to rapid make and break at the contact, arising from irregularities in the surface of the disc. The mathematical theory of the phenomenon is investigated at some length. F. T. C.

125. *Subsequent Magnetism of Iron.* A. Bernini. (N. Cimento, 4. Ser. 6. pp. 188-148, Aug., 1912.)—The paper is the third of a series and deals with the law according to which the specimen attains its final steady condition for decreasing magnetisation, the former papers [Abstracts Nos. 590, 1114 (1912)] having dealt with the similar phenomenon for increasing field. The same equation containing two constants is found to apply as in the former case; the constants are, however, not in general the same, but become so in the case in which there is residual magnetism. (Addendum, Ibid. p. 256, Sept.)

S. G. S.

126. *Measurement of Magnetic Field Intensity.* W. Rogowski and W. Steinhaus. (Archiv. f. Elektrotechnik, 1. pp. 141-160, 1912. Communication from the Physikal.-Techn. Reichsanstalt.)—The magnetic properties of a material are usually given by a curve showing B as a function of H. While the former quantity is easily measured by ballistic and other methods, the latter is difficult to measure. To overcome this difficulty the authors propose to use a coil which they term a magnetic intensity meter. The flux in a uniformly-wound coil which has everywhere the same cross-section is proportional to the magnetic force between the beginning and end of the coil, and the direction of this force is along the axis of the coil. Such a coil can be used as a magnetic intensity measurer. The method of experimenting lies in the measurement of the closed line integral of magnetic force. This according to theory should be constant for all paths which involve the same circulation and should vanish if there is no flow in the enclosed circuit. If iron is brought into the field it can distort the magnetic field, but the line integral of magnetic force should be unchanged. In the paper the authors give an account of the practical application of this principle to the measurement of H in yoke and other such magnetic tests. A. D. R.

127. *Effect of Quenching on the Magnetic Properties of Metals and Compounds.* K. Honda. (Mathematico-Physical Soc., Tōkyō, Proc. 6. 19. pp. 82-285, vol. XVI.—A.—1918.

Sept., 1912.)—The author discusses the question as to whether quenching can be considered effective in fixing at room temperature the properties of a material corresponding to high temperatures. From tests on various metallic elements, alloys and compounds, he considers that in general quenching is ineffective. The manganese steels, however, are an exception to the general rule. A. D. R.

128. *Hysteresis of Iron under Electrical Oscillations.* H. Fassbender and E. Hupka. (Jahrbuch d. Drahtlosen Telegraphie, 6. pp. 188-146, Sept., 1912. Communication from the Physikal.-Techn. Reichsanstalt.)—A more complete account of the work dealt with in Abstract No. 985 (1912).

RADIOLOGY AND ELECTROPHYSIOLOGY.

129. *Intensity Distribution of Röntgen Rays from a Platinum Antikathode.* W. Friedrich. (Ann. d. Physik, 89. 2. pp. 377-480, Sept. 24, 1912. Extract of Dissertation, Munich.)—The first researches dealing with the intensity distribution of Röntgen rays were undertaken by Röntgen in 1897. Using a photometer method he compared the intensity of the light on a barium platinocyanide screen placed in different emission directions at equal distances from the antikathode. He also exposed photographic films bent in a semicircle round the Pt antikathode. From his results he came to the conclusion that the Röntgen rays had an approximately uniform intensity distribution. He noticed a slight decrease with emission angle 80° , while the main alteration in intensity appeared to take place between 89° and 90° . More recently B. Walter, who repeated Röntgen's photographic experiments, found that when allowance is made for the want of uniformity in the walls of the tube, the intensity distribution is approximately uniform. He attributes the rapid decrease in intensity for angles greater than 80° as observed by Röntgen, to absorption of Röntgen rays by the antikathode. In the present paper the dependence of the intensity on the azimuth is the object of research, special consideration being given to variations due to tube-wall; both photographic and electrical methods being employed. In general very similar results are obtained by the two methods. As a rule, the ionisation method is employed for quantitative measurements. It is found that the intensity of Röntgen rays emitted by a Pt antikathode (after passing through a uniform thickness of 2 mm. tube-wall) are dependent upon the azimuth, i.e. on the angle which the axis of the pencil of kathode rays makes with the axis of the pencil of Röntgen rays generated by them. The max. intensity does not lie in a direction at right angles to that of the propagation of the kathode rays, but is displaced to the side of azimuth less than 90° . The greater the hardness of the rays the larger is this displacement. The measurement of the intensity distribution by the electrical method gives a mean difference between rays of azimuth 150° and those of azimuth 80° , of 20%. The hardness of the Röntgen rays is also a function of the azimuth. It increases with diminishing azimuth. By photographic means it is shown that a minimum of Röntgen-ray intensity generated by a Pt antikathode and having passed through 0.01 mm. of Al occurs at azimuth 0° . A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

130. *Adsorption of Gases by Carbon and other Porous Substances.* W. Hempel and G. Vater. (Zeitschr. Elektrochem. 18. pp. 724-727, Aug. 15, 1912. G. Vater, Dissertation, Techn. Hochschule, Dresden.)—Experiments were made with different kinds of charcoal, kieselguhr, bog ore, spongy platinum, bone ash, peaty earth, etc. It results that blood charcoal absorbs all gases (H , O , N , A , NO , H_2S , CO , CO_2 , CH_4 , C_2H_6 , Cl , NH_3), etc., much better, at $+20^\circ$, -78° , $-185^\circ C.$, than cocoa-nut charcoal; gas-analytical separations of diatomic gases are not possible by these means, however. Much depends upon the temperature at which carbonisation takes place; the best temperature for both charcoal and the authors' special blood charcoal is $600^\circ C.$ H. B.

131. *Connection between the Chemical Characteristics of Radio-elements and the Series of Radio-active Transformations.* G. v. Hevesy. (Phys. Zeitschr. 18. pp. 872-878, July 15, 1912.)—RaC separates itself electrolytically more easily than RaB, RaF more easily than RaE, and so on. These facts lead to the generalisation that radio-active transformation always takes place in such a direction that the existing product is electrochemically more stable than the disintegrating one. This is known as the Lucas-Lerch law. To investigate the correctness or otherwise of this law the author examined the behaviour of RaA whose period is of the same order of magnitude as those of RaB and RaC. The active deposit was obtained on a small piece of Na metal, with which also the active deposit existing on the surface of the latter very quickly went into solution. The alkaline solution was neutralised with H_2SO_4 , copper sulphate added and a copper plate dipped for 45 secs. in the solution. A curve showing the result is given. The active deposit was collected during 12.5 mins. and the copper plate dipped in the solution 4.8 mins. after the interruption of the exposure. The simple relation which is observed between the chemical and other peculiarities of the radio-elements is this, that the radium transformation products yielding α -rays: RaF, RaC, and RaA—are more easily deposited than the β -products. The examination of the electrochemical behaviour of RaA—which shows itself more stable than RaB but less stable than RaC—affords a further decisive example that there exists no thorough connection between the electrochemical behaviour of the radio-elements and the order of succession of radio-active transformations. J. J. S.

132. *Influence of Vortex Motion on the Structure of Liquid Crystals.* Lehmann. (Ann. d. Physik, 89. 1. pp. 80-110, Sept. 5, 1912.)—The view is adopted that apart from the surface, where the molecular structure is rendered anisotropic by friction, crystalline fluids of small viscosity show the same hydrodynamic stream-lines as ordinary amorphous fluids. The molecular structure is not affected by flow if the orientation of the molecules is maintained by contact with solid substances or strong magnetic fields. T. M. L.

133. *Optical Investigation of Crystallised Nitrogen, Argon, and Methane.* W. Wahl. (Roy. Soc., Proc. Ser. A. 87. pp. 871-880, Oct. 2, 1912.)—The substances were crystallised and examined in a quartz glass vessel, holding a

very thin layer (0.05 mm.) of substance between polished glass plates. It was found that nitrogen, argon, and methane crystallise in the cubic system. Ethyl ether is rhombic; ethyl alcohol, acetone, methyl alcohol and carbon disulphide are monoclinic or triclinic. Methyl alcohol occurs in two polymorphic forms, changing reversibly into each other. T. M. L.

134. *Crystallisation of Cold-worked Metals effected by Annealing.* F. Robin. (Comptes Rendus, 155. pp. 585-587, Sept. 28, 1912.)—The author has annealed thin (0.5 mm. thick) cold-rolled plates of various metals at various temperatures and has observed the crystal growths. The results indicate that the growth does not increase in proportion to the temperature if the time of heating is kept constant, and it appears that for pure metals and solutions the largest grains are not always obtained at the highest temperature, nor the smallest at the lowest temperatures of heating. Generally speaking, impurities reduce the scale of the grain-size without sensibly affecting the temperature at which annealing begins. The degree of reduction varies considerably with the nature of the impurity. Aluminium and magnesium have the greatest effect on tin, lead and zinc. F. C. A. H. L.

135. *Relations between the Macrostructure and Crystallisation of Steel.* N. T. Belaiew. (Soc. Métallurg. russe, Journ. 1. pp. 21-88, 1910. Rev. de Métallurgie, 9. pp. 647-680, Sept., 1912. Paper read before the Congrès des Mines, de la Métallurgie, et des Constructions mécaniques, Ekaterinoslaw, Sept. 1, 1910.)—From a long series of observations of the macrostructure of both ordinary and alloy steels and an examination of the developed crystals often found in the pipes and cavities in ingots, the author concludes that cast steel is composed, both externally and internally, of crystals similar to those developed in pipes and cavities. The size, shape, and distribution of the crystals depend upon the mass, section, and composition of the ingot and also upon the process of cooling, etc. These crystals are produced during the period of solidification and their formation is revealed by the macrostructure which is a result of irregularities in composition and is typical for all classes of steel. Generally speaking, the macrostructure cannot be modified at the temperatures attained in the course of ordinary thermal or mechanical operations, so that it really represents the stable structure of the steel. Cold mechanical work only produces deformation of the crystals, while hot treatment only produces local changes in each of the particles constituting the macrostructure. Consequently the difference between the three types of steel is: (1) cast steel is made up of crystals of various shapes and sizes arranged haphazard, (2) mechanically worked steel consists of the same crystals more or less displaced according to the nature and degree of working, and (3) thermally worked steel is always made up of the same primitive crystals either in their natural or deformed state, but the constituent parts of the crystals have been altered as a result of equilibrium changes determined by the temperature and other conditions of the thermal treatment. F. C. A. H. L.

136. *Exothermic Steel.* W. O. Amsler. (Metallurgical and Chem. Engin. 10. pp. 559-562, Sept., 1912.)—This steel is produced by an exothermic reaction according to the equation $\text{Fe}_2\text{O}_3 + 2\text{KAlSi}_2\text{O}_6 + 2\text{Al}_2\text{O}(\text{OH})_3 + \text{CaO} = 2\text{Fe} + 4\text{Al}_2\text{O}_3 + 6\text{SiO}_2 + 2\text{KOH} + \text{CaO} + 8\text{H}_2\text{O}$, which takes place when iron oxide, felspar, bauxite and lime are heated together. Excess

iron oxide and the corresponding amount of charcoal are added to keep down the temperature, which may rise very high. The reaction is carried out in a stack furnace heated by an oil burner and the products of combustion are drawn off at the top by means of an exhauster and passed through a scrubber. Carbon is added in an open-hearth furnace and the resulting metal is unusually quiet, giving an ingot free from pipe and segregation. Tests on 1.16 per cent. carbon steel made in this way showed that a 1-in. octagon bar would bend double without a sign of fracture. It is claimed that the steel gives from two to five times the service of the best nickel steel forgings.

F. C. A. H. L.

137. *Cryoscopy in Sodium Sulphate Decahydrate as Solvent.* A. Boutaric and C. Leenhardt. (Comptes Rendus, 155. pp. 825-826, Oct. 28, 1912.)—The "molecular depression" produced by urea in sodium sulphate was found to be 82.06. The value calculated from the latent heat by van't Hoff's formula was found to be 82.08.

T. M. L.

138. *Investigation of Chemical Reactions taking place at Kathode and Anode during Electrolysis of Simple Salt Solutions.* J. H. Paterson. (Univ. of Durham Phil. Soc., Proc. 4. pp. 187-220, 1911-1912.)—The author has devised a special microscopic cell by means of which the kathode reactions of the metals Co, Ni, Fe, Zn, Cd, Mn, Pb, and Sn have been investigated. A number of experiments were also carried out on a larger scale. The experiments with the microscope cell have shown that it is possible to obtain from a number of these metals (Co, Ni, Fe, Zn, Cd, Mn, and doubtfully Pb) either the pure metal or the hydroxide deposited on the kathode. Observations on the conditions of concentration and current density necessary to produce these substances show that as we proceed along the list of metals in the order written, the dilution necessary to produce the hydrate increases and the limit of current strength decreases. The hydroxide of the metal is not produced as a secondary reaction of the metal deposited on the kathode, but is formed as a precipitate from the electrolyte in the kathode area. The formation of the metal or hydroxide according to the varying conditions can readily be explained by the application of Nernst's theory of potential and over-voltage. In view of the fact that the hydroxides of nearly all the metals above hydrogen in the potential series can be found at the kathode, it is probable that the spongy metallic deposits produced by the use of too high current densities contain the hydroxides of the metals as impurities, if they contain any impurities at all. With respect to anode reactions, the chemical conditions under which precipitates are obtained vary considerably. With Ni and Co, for example, anode precipitates are not produced under any conditions when simple salts are used, but are produced readily enough when sufficient ammonium sulphate or nitrate is added to produce the double salt, and disappear again on adding excess of the salt or of ammonia. With Ag and Pb, on the other hand, precipitates are produced on the electrolysis of the simple nitrates, and with manganese on the electrolysis of any of its salts. All the metals which produce anode deposits are metals having valencies of two or more orders of magnitude.

T. S. P.

139. *Rapid Electro-analysis under diminished Pressure.* F. Fischer and E. Stecher. (Zeitschr. Elektrochem. 18. pp. 809-816, Sept. 15, 1912.)—The method already described [see Abstract No. 118 (1912)] has been further tested in the estimation of single metals, as also in separations. Zinc, like

copper, can only be rapidly estimated under diminished pressure when the temperature is high. The method is suitable for the estimation of Ni, but not particularly so for the estimation of lead as dioxide. Good results were obtained in the estimation of Cu in brass, the separation of Cu and Ni, and the separation of Ag and Cu. In the latter case neutral or acidified solutions of the sulphates were used, and Brunck's method of using an Edison accumulator was adopted. The advantage of the use of diminished pressure is shown by the fact that 0.1 gm. of silver can be deposited in 15 minutes, whereas Brunck's method requires about an hour to do this, and the complete determination of Ag and Cu occupies only three-quarters of an hour. A special arrangement for washing a deposit without interrupting the current is described.

T. S. P.

140. *Influence of Colloids on the Electrolytic Deposition of Lead.* H. Freundlich and J. Fischer. (Zeitschr. Elektrochem. 18, pp. 885-891, Oct. 15, 1912).—From various theoretical considerations the authors come to the conclusion that the formation of an electrolytic deposit depends ultimately (1) on the number of crystal nuclei formed from the discharged metal atoms; (2) on the velocity of crystallisation of the metal on the surface of the electrode. If (1) is small in comparison with (2) the crystal nuclei will grow quickly to large crystals, the discharged metal atoms being used up in this way without having the opportunity of forming new nuclei; the deposit will consequently be coarse and crystalline. On the other hand, if (1) is large in comparison with (2), supersaturation occurs with respect to the discharged metal atoms, so that fresh nuclei will continually be formed and consequently a larger number of small crystals, giving a compact deposit. Marc has shown that colloids have a very considerable effect in diminishing the velocity of crystallisation, which is in favour of the above theory. For a number of colloids (gelatine, agar-agar, casein, traganth, and dextrine) the authors have determined the minimum quantity necessary to give a good deposit of lead, under given conditions of current density and time, from solutions of the perchlorate and silicofluoride, and also the protective action of such colloidal solutions on a gold hydrosol. The two things are not exactly parallel, but the results of the experiments allow of the interpretation that the colloids are absorbed by the metal, thus reducing the velocity of crystallisation and favouring a compact deposit. Further evidence in support of the assumption that the velocity of crystallisation is the deciding factor is found in the fact that gelatine has a similar influence on the nature of the deposit of lead obtained by immersing zinc in solutions of the lead perchlorate and silicofluoride to what it has on the electrolytic deposit.

T. S. P.

141. *Dependence of Crystal Form on Temperature.* G. Tammann. (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 5, pp. 557-565, 1912).—Deals with about twenty inorganic compounds.

E. H. B.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1913.

GENERAL PHYSICS.

142. *Bessel's Measuring Apparatus.* P. Thomas. (Kaiserl. Normal-Eichungs Kommission, Wiss. Abhandl. No. 8. pp. 118-148, 1912.)—Research during the years 1908, 1909, and 1910 with Bessel's apparatus has led to the following results:—(1) The readings of the metal thermometer do not bear unique relations with the observed temperatures, as has usually been supposed up to the present, but are dependent also on previous temperature variations. (2) The measurements carried out in 1880 with Bessel's apparatus gave results somewhat too large in consequence of the effect of thermal after-action. (3) Several variations of length of the different rods used were noted between 1908 and 1910, contractions being observed of from 0.01 to 0.06 mm. A. W.

143. *Large Comparator.* W. Kösters. (Kaiserl. Normal-Eichungs Kommission, Wiss. Abhandl. No. 8. pp. 87-109, 1912.)—Describes at length, with numerous illustrations, the construction and use of the large comparator used by the above Commission. A. W.

144. *A Standard Measuring Machine.* P. E. Shaw. (Roy. Soc., Proc. Ser. A. 87. pp. 885-890, Oct. 31, 1912.)—Gives an outline of the scope of an improved type of machine constructed by the author on the principle of electric touch [Abstract No. 1116 (1906)] and now installed at the National Physical Laboratory. Details and tables of results are to be given later. L. H. W.

145. *Ruler for Drawing Curves.* Berkeley. (Phil. Mag. 24. pp. 664-668, Oct., 1912.)—Describes an adjustable form of steel ruler, which may be bent so as to pass through a number of points. Two metal T-squares each carry two slotted pegs, one on either arm of the head, and these pegs can be placed at any point along their respective arms. Through the slots in these pegs passes a long flexible steel ruler, which, in the apparatus described, was 1.5 m. long, 5.7 cm. wide, and 2.4 mm. thick. The long arms of the T-squares each carry a projecting peg, adjustable in position along the arm, and round

these pegs a cord passes, provided with an arrangement for shortening or lengthening as desired. By varying the relative positions of the various pegs and by altering the tension on the cord, the ruler can, within fairly wide limits, be made practically to coincide with any simple curve. If the curvature change sign the ruler cannot in general be made to follow the curve; but if the inflection be near the end of the curve, adjustment is possible if on the long arm of one of the squares the peg carrying the cord is brought near the head, while at the same time that on the other square is some distance from the head, so that the line joining these pegs passes between the two pegs on the head of the first T-square. A. W.

146. *Length Standard and Thermal Expansion of Copper.* G. F. K. Langbein. (Kaiserl. Normal-Eichungs Kommission, Wiss. Abhandl. No. 8. pp. 151-167, 1912.)—Describes the elaborate series of tests of the principal length standard of the Commission, and the determination of the thermal expansion. A. W.

147. *Elastic Peculiarities of Platinum-Iridium Wires.* L. P. Sieg. (Phys. Rev. 85. pp. 847-858, Nov., 1912.)—Further investigation of the elastic properties of Pt-Ir wires shows that in spite of a peculiar variation of period with amplitude and of an enormous change in the decrement of these wires as they die down in their vibrations, they obey Hooke's law both statically and kinetically, and their torsional vibration is practically angular harmonic. The elastic properties vary with the period of vibration, and are profoundly modified by long-continued rest under load, and by drawing the wires. It is concluded that these phenomena are related to the crystalline structure of the alloys, which appears to be exceptionally sensitive to such treatment as annealing and drawing. [See also Abstract No. 10 (1911).] W. H. S.

148. *Elastic Strength of Flat Plates.* W. J. Crawford. (Roy. Soc. Edinburgh, Proc. 82. pp. 848-889, 1911-1912.)—Owing to the abstruse mathematics involved in the general case of a thin isotropic plate, exact elastic equations have been obtained only for circular and elliptical plates. Grashof has, however, obtained approximate relations for square and rectangular plates. In the present work, planished steel plates were clamped between duplicate forming-blocks of the desired shape and subjected to oil pressure. The condition was thus obtained of a uniformly loaded plate clamped at the edges. Deflections were read by a micrometer screw-gauge with reference to a bar fixed relative to the base of the apparatus. A Starret dial test indicator and an optical indicator were also used, but the micrometer was found to be the most convenient and accurate. A zero error was evident in all cases, being due to small initial irregularities in the plates and to minute yielding at the fixed edges. A typical pressure-deflection curve consists of an initial curved portion, showing instability in the plate, followed by the straight elastic line, from which the theory is tested. Finally, at a load of from 2 to 6 times that which causes the first permanent set, the line again curves, showing increased resistance to bending as the plate assumes an arched form. It was concluded that measurement of central no-load deflections after application of pressure gives a most delicate indication of the exact pressure for initial failure, no matter where it occurs; for the plate is in the position of an encasté beam, so that yielding at the ends or any other part produces a maximum set at the centre. The results obtained for circular plates confirm very closely the value $f_1 = (2/8)(r^2/E)p$, where $f_1 = \max$.

elastic stress on theory of max. principal strain, r and t are radius and thickness of plate, p = pressure in lbs. per sq. in. for initial permanent set. This formula assumes a value of 8 for Poisson's ratio and has to be corrected for the experimental value, 8.19, for the material tested. The results show clearly that the mathematical analysis is correct and that the max. principal strain is the criterion of failure. It is difficult to detect the pressure for initial failure in square and rectangular plates since all the circumferential fibres do not fail simultaneously, as with the circle. The central deflection readings confirm Grashof's formula for a square plate $v = (1/64)(pb^4/Et^3)$. A graphic analysis of curvature is made for the square and rectangular plates by plotting deflections, y_1 against distances, x_1 along the diameters and several lines lying between, for a steady pressure. By differentiating twice graphically the stress $f_1 = (t/2)E \cdot d^2y/dx^2$ can be mapped over the plate. Grashof gives a value $f_1 = (2b^4/a^4 + b^4)(a^2/t^3)p$ as equivalent to the greatest stress at the ends of a long diam. $2a_1$ with a symmetrical form for the short diam. $2b$. In nearly every case the experimental value $(t/2)E \cdot d^2y/dx^2$ is greater than Grashof's, a suggested safe factor for design being 1.25. Ribs for stiffening should be placed parallel to the edges, not diagonally, and should be stouter at the ends than at the centre. **C. G. Knott.** (*Ibid.* 82. pp. 890-892, 1911-1912.) Crawford's results are in good agreement with Ritz's solution for the deflection of any point in a clamped rectangular plate under uniform pressure, the figures being carried to a third approximation.

E. J. S.

149. The Circular Diagram of Stress and its Application to the Theory of Internal Friction. **O. H. Basquin.** (*West. Soc. Engin., Journ.* 17. pp. 815-847; Discussion, pp. 847-849, Nov., 1912.)—In the first part of the paper the general case of the stress at a point in a homogeneous body is investigated following the lines of Mohr's classic work. In most discussions of the two-dimensional case, when the ellipsoid of stress degenerates into an ellipse, it is assumed that one principal stress is zero. The author points out that this is unnecessary if stresses only, without their attendant strains, are considered, for one principal stress has no effect on planes parallel to its own direction. For this case if p_x and p_y are principal stresses at a point in a plane inclined at an angle θ to p_y , p and q being the nominal and shear stresses at the point, then—

$$p = (p_y + p_x)/2 + (p_y - p_x)/2 \cdot \cos 2\theta$$

and—

$$q = (p_y - p_x)/2 \cdot \sin 2\theta.$$

This is shown graphically by setting out p_x and p_y along the axis of abscissæ and describing a circle on $p_y - p_x$ as diam. The co-ordinates of the end of a chord drawn from the end of p_x at angle θ to the axis are respectively the normal and shear stresses on the plane θ . The circle diagrams for a number of problems are described. If a point be taken on the axis of ordinates at height k_s = the pure shear strength of the material and a line be drawn through this point inclined at the angle of internal friction, ϕ , then the ordinate q corresponding to any abscissa p is $k_s + p \tan \phi$. This is the value assumed by Navier to be given to the shear strength under a normal stress p by the influence of internal friction, and the line described is called the line of slip. The circle diagram corresponding to any set of stresses which causes failure must be tangent to the line of slip. The increase of compressive strength due to friction is confirmed in practice for brittle materials.

If the theory holds for ductile materials the compressive yield should be 70 % more than the tensile but this is not confirmed. The discrepancy is attributed to unavoidable eccentricity of load. The case of combined stresses is discussed, and compared with Robertson and Cook's results for thick cylinders under pressure. The internal friction theory agrees closely with the experimental data. Rankine's theory of earth pressure is discussed graphically. An experiment is described in which sand in a horizontal cylinder is compressed by a ram till the lateral stress due to the principal stress applied just raises a weight closing a hole in the cylinder. By varying the weight a number of circle diagrams are obtained for the pairs of principal stresses which are all approximately tangential to the line of slip at an angle equal to that of repose of the sand if it is of great depth. The circle diagram illustrates the fact that, for small depths, the angle of repose becomes greater than the friction angle owing to cohesion. Finally the case of a pile is considered, and it is shown that in order to obtain the largest value for the minimum load, a tapered pile should be driven with its large end downward.

E. J. S.

150. Hardness. Hanriot. (*Comptes Rendus*, 155, pp. 718-716, Oct. 14, 1912.)—In the Brinell hardness test, the use of small balls under low loads gives lower values than the use of larger balls under correspondingly greater loads. The results of a number of tests on various metals and alloys indicate that this is due to the increased hardening effect of the larger ball and high load. As a result the hardnesses of annealed metals are always found too high. Another source of error lies in the fact that owing to the elasticity of the metal, the impression becomes smaller when the pressure is removed.

F. C. A. H. L.

151. Mechanical Hardening. Hanriot. (*Comptes Rendus*, 155, pp. 828-831, Oct. 28, 1912.)—Cold working affects not only the elastic limit but the whole of the mechanical properties of a metal. Some metals are in a state similar to that of the cold-worked, after electro-deposition. The author regards annealing as the inverse of cold working, and regards a metal as cold-worked or mechanically hard when annealing alters its physical properties without changing its chemical composition. As a measure of mechanical hardness the ratio of the ball hardness in the unannealed to that in the annealed state is proposed. It is shown that ball hardness gives a better indication of mechanical hardness than does tensile strength and elongation. By means of a 8-mm. ball under a load of 80 kg. the author has been able to determine the hardness of brittle metals like Bi and Sb. While Bi is very little harder than Pb, Sb gives a very high value.

F. C. A. H. L.

152. The Solidification of Metals from the Liquid State. G. T. Beilby. (*Inst. of Metals, Journ.* 8, pp. 186-191, 1912. *Engineering*, 94, p. 427, Sept. 27, 1912.)—The author indicates briefly the lines on which it is intended to work. The problem for solution proposed by the committee appointed by the Council of the Institute of Metals is: "Does molecular aggregation occur in liquid metals immediately before solidification either by the formation of liquid crystalline units or by the segregation of globules enclosed in foam cells?" Quincke holds the view that a foam-cell structure precedes, and persists after, solidification. The author has already shown that solidified gold globules consist of sac-like grains which retain their individuality even after deformation. Annealing of strained metals brings

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about a recrystallisation of quite a different type, and it is proposed to distinguish the two types of crystallisation as "primary" and "secondary." It is mainly crystals of the primary type which are affected by the foam-cell formation, but the question arises: "Are the cells formed while the metal is still liquid or in the final stage of crystallisation and, if in the former, are the initial stages brought about by liquid segregation and surface tension or by the crystalline aggregation of molecules in the liquid state?" Watched under the microscope, crystallisation in thin films appears to start from isolated nuclei and to proceed radially. Under high magnification it appears that the radii from adjoining nuclei stop short before they actually meet, so that when solidification is complete it appears as if a network had been spread over the surface. There can be no doubt that the resulting cell-like structure is entirely controlled by the nuclei, and has no relationship with any foam-cell structure which may have previously existed in the liquid. While this does not negative Quincke's hypothesis, it removes the necessity for its postulation; but it is hoped that the inquiry will have a greater scope than the proof or disproof of the foam-cell theory.

F. C. A. H. L.

153. *The Effect of Temperature on Tensile Tests of Metals.* A. K. Huntington. (Inst. of Metals, Journ. 8. pp. 126-144; Discussion, pp. 145-148, 1912. Engineering, 94. pp. 487-489, Sept. 27, 1912. Mech. Eng. 80. pp. 465-469, Oct. 11, 1912.)—Various results are given showing the effect of temperatures higher than atmospheric on tensile tests of copper and its alloys and comparing these with wrought iron and steel. The tests were made with a horizontal machine of the Kirkcaldy type, and the test bars were of two patterns: one for use with high-temperature thermometers, and the other for use with thermo-electric couples. Details are given of the method used in carrying out the tests, also tables of results for electrolytic copper, arsenical copper, copper-tin alloy, copper-nickel, copper-aluminium, copper-zinc, mild steel, and wrought iron. On taking the electrolytic copper as a standard of comparison and comparing with it the copper alloys, it is seen that, broadly speaking, they have the same characteristics. The curves obtained for the yield-points approximate to straight lines, except in the case of copper-zinc, and the breaking-load curves closely approximate to straight lines, but show signs of being influenced by the second metal at the higher temperatures. The most distinctive curves are those for elongation and reduction of area, which show the preponderating influence of the copper and the modifying effect of the added metal. Considerable differences are shown in the various curves given for mild steel and wrought iron when compared with the others; in the yield-point curves, the only resemblance to iron and steel is found in the copper-zinc alloy.

C. O. B.

154. *Testing with a Freely Falling Ball.* J. J. Schneider. (Rev. de Métallurgie, 9. pp. 569-577, Oct., 1912.)—There can be no doubt that hardness measured by shock is different from that measured by means of a gradual pressure. Using an apparatus which consists essentially of a ball allowed to fall freely by means of a sort of iris diaphragm, the author has investigated the variation of the diam. of the impression with the work done; the variation of the diam. of impression with the diam. of the ball; and the increase of dynamic hardness after the rebound. The paper is too detailed for a short abstract, and should be consulted for further information.

F. C. A. H. L.

155. Universal Testing Machine. M. Kurrein. (Zeitschr. Vereines Deutsch. Ing. 56. pp. 1948-1946, Nov. 30, 1912.)—Describes a 80-ton testing machine for tension, compression, bending, torsion, and shear experiments. The transforming from one kind of experiment to another occupies only 4 minutes, and accessibility is an important feature. Six illustrations are given. H. S. R.

156. Calculation of Stress-distribution in Cylindrical Vessels with Variable Cross-section. T. Pöschl. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1185-1160, June, 1912.)—Mathematical.

157. Theory of Taper Columns. W. M. Wallace. (Engineering, 94. pp. 881-882, Dec. 20, 1912. From the Journ. of the Assoc. of Teachers in Technical Institutions.)

158. Novel Illustrations of Gyrostatic Action. J. G. Gray. (Roy. Soc. Edinburgh, Proc. 82. pp. 406-415, 1911-1912.)—The author describes, with illustrations, some new forms of gyroscopic apparatus which he has devised. These comprise: a stilt top, a gyrostatic bicycle-rider, and two forms of acrobatic top. The gyro wheels are in all cases brought up to speed by being pressed against a leather disc on the spindle of an electric motor. L. H. W.

159. Motion of Sphere in Viscous Liquid. U. Cisotti. (Comptes Rendus, 155. pp. 641-644, Oct. 7, 1912.)—Deals on the method of energetics with the uniform motion of a sphere in an extended viscous liquid. On the assumption of no slipping at the surface of the sphere, the classic formula of Stokes is obtained. The case of a dry surface is then dealt with by aid of Rayleigh's dissipation function. The paper concludes with reference to certain limiting cases, and compares the resistances to that in Stokes' formula. E. H. B.

160. Propagation of the Explosive Wave in Solids. J. Taffanel and H. Dautriche. (Comptes Rendus, 155. pp. 1221-1224, Dec. 9, 1912.)—The authors discuss the propagation of the explosive wave in solids. They limit the case to cylindrical propagation, and have assumed, as experience seems to justify, that the permanent state is attained. In rectilinear propagation they get from physical principles four equations to determine the five unknown quantities. There are, therefore, an infinite number of types of waves which satisfy these conditions. Assuming that the required wave has a maximum velocity a solution is obtained. They point out that since the velocity of detonation can be measured experimentally to a high degree of accuracy, it is possible to obtain in this way important information about the other variables. A. R.

161. The Ether. D. L. Webster. (Amer. Acad., Proc. 48. 12. pp. 511-527, Nov., 1912.)—A treatment, largely mathematical, of the existence and properties of the ether. The ether (or electromagnetic) equations, including gravitation and relativity principle, are reduced to five: a pair for the electric field, a pair for the magnetic field, and one expressing Hamilton's principle. As to the structure of the ether it is concluded that, if granular, the structure must be exceedingly minute compared to the dimensions of the electrons. The idea is put forward that the ether may be a medium in which there are two similar, but slightly different, interlacing granular structures, whose grains and distances apart are inconceivably small, VOL. XVI.—A.—1913.

even compared to electrons. As to fluidity or solidity, the author concludes that the ether is "solid" in the sense that every particle is permanently connected to the particles near it by connections that cannot be deformed indefinitely, or even by a finite amount without affecting the subsequent motion. A model of the ether, consisting of two interlacing cubical meshes and knots, is then described. F. H. B.

162. *The Dense Haze of June 10-11, 1912.* H. H. Kimball. (Mount Weather Observatory, Bull. 5. 8. pp. 161-165, 1912.)—On the 8th and 9th of June the atmosphere at Mount Weather was unusually clear, but by the 10th the upper layers were filled with a white veil of haze. On the 11th this dense haze persisted above, while the lower layers were becoming less clear. On the 12th the haze had become light in the upper atmosphere, but was dense below. A strong odour of smoke was noticeable. Observations on the radiation received at the earth's surface and on the polarisation of sky light during the period are recorded. It is concluded that the upper limit of the haze was at 8 km. height. The weather at the time was anticyclonic, and the suggestion is put forward that the haze consisted of dust particles carried up by convection currents in the still air. J. S. DI.

163. *Influence of Clouds on the Distribution of Solar Radiation.* H. H. Kimball and E. R. Miller. (Mount Weather Observatory, Bull. 5. 8. pp. 166-172, 1912.)—The paper gives an account of certain cases in which the presence of clouds in the sky increased the radiation recorded by a Callendar pyrheliometer. A typical case was afforded on Feb. 5th, 1912, at Madison, where at 11.40 a.m. a bright sheet of alto-stratus advanced from the north-west. The recorded radiation rose as the clouds approached the sun to a maximum of 1.11 gm. cal. per cm.² per min. when the edge of the cloud reached the sun, and then fell off rapidly. The record from Feb. 8rd, a perfectly clear day, afforded a good comparison, and from this it is deduced that the presence of the cloud sheet increased the radiation 41% above what would have been its value with a clear sky. Several other examples are quoted in which the increase varied from 8 to 20%. With thin sheets of cloud of the alto-stratus type, the effect is ascribed to radiation transmitted through the cloud by refraction and reflection, while with heavy cumulus clouds reflection off the surface is regarded as the cause. J. S. DI.

164. *Solar Radiation Intensities at Madison, Wisconsin.* H. H. Kimball and E. R. Miller. (Mount Weather Observatory, Bull. 5. 8. pp. 178-183, 1912.)—The instrument employed at Madison was a Marvin pyrheliometer, the exposure and standardisation of which are discussed in considerable detail. The observations are compared with those made at Washington, and it is found that while the differences between the intensities at the two stations are unimportant for the warm months of the year, the radiation at Madison shows a pronounced excess over that at Washington for the cold months. After reviewing various causes which might be productive of this result the authors reach the conclusion that in winter, when the northern parts of the United States are generally covered with snow, the atmosphere at Madison contains much less dust than that at Washington. J. S. DI.

165. *Climate of British Columbia.* (Bureau of Provincial Information, Victoria, B.C., Bull. No. 27. [82 pp.] 1912.)—Gives tables of rainfall, snowfall, and temperature; altitudes of places, lakes, and mountains. L. H. W.

LIGHT.

166. *A Chromoscope*. **L. Arons**. (Ann. d. Physik, 89. 8. pp. 545-568, Oct. 15, 1912.)—In the finished instrument [see Abstract No. 41 (1911)], any colour can be determined in terms of the colours obtained from the standard quartz plates by means of a Lummer-Brodhun photometer head. The brightness of the colour is indicated by the circle-scale readings of two Nicol prisms. Thus in the newer instrument four numbers are required to designate the colour under test as to tone, saturation and brightness. The quartz plates are in two systems, but a wide range of colour measurement can be made using one system only. It is considered by the author as one of the greatest advantages of the use of the chromoscope that a colour can be reproduced at any time from its four characteristic numbers alone. In an appendix, the determinations of a number of optical colour-filters by means of the chromoscope are given.

G. E. A.

167. *New Reflection Ocular*. **P. G. Nutting**. (Washington Acad. Sci., Journ. 2. pp. 404-406, Oct. 4, 1912.)—In the ordinary Gauss reflection ocular, as used with a refracting telescope, rays from a lamp pass through a side orifice in the tube, and fall upon an unsilvered glass plate set at 45° to the optical axis. The beam thus reflected towards the objective illuminates the cross-threads directly, while the field is illuminated by means of light reflected back from the objective. In the course of the instrumental adjustments for which the ocular is employed, it is necessary to bring the bright cross-threads into coincidence with their dark reflected image [reflected from a mirror outside the objective], the field being moderately illuminated. The conditions of this process are unfavourable to high precision, and moreover the reflected image is frequently difficult to pick up. In the new form of ocular the glass plate at 45° is replaced by the narrow reflecting face of a very thin prism, consisting simply of a slip of microscopic cover-glass, about 15 by 5 by 0.2 mm., having one end sliced off at 45° . It is this slant end which acts as reflecting face. The slip is inserted through a side tube, at right angles to the main tube, and is attached by wax to a metal plug with a knurled head, half the plug being cut away. The thin edge of the glass being presented to the eye, the slip interferes very little with the visual beam. Adjustment consists in bringing the black rear of the reflecting face into coincidence with the bright reflected image of its front, which is stated to be brilliant and easily seen in any part of the field of view. The field illumination is low owing to the smallness of the entering beam. The new ocular can be used for photometry by rotating the reflecting face 180° so that it faces towards the eye instead of towards the objective. Uniform illumination is secured by placing a fragment of opal glass over the orifice where the illuminating beam enters. This method has been used for measurements of diffuse light, but has not yet been tried for extra-focal star images. The thin reflecting prism has also been used successfully in microscopes for illuminating the object viewed.

A. E.

168. *Influence of Physical Conditions of a Substance on its Absorption of Light*. **G. H. Livens**. (Phil. Mag. 24. pp. 623-628, Oct., 1912.)—In a previous VOL. XVI.—A.—1918.

paper [Abstract No. 1889 (1912)] the author discussed theoretically the effect of the density of a gas on its line spectrum. The theory can be extended to give explanation of other experimental facts concerning the effect of the physical conditions of a substance on its absorption of light. The present paper deals with (i) The influence of the nature of the solvent upon the position of the absorption bands of the dissolved substance. (ii) Absorption in a gas. (iii) The broadening of the lines of a spectrum with increasing density. A. W.

169. Spectropolariscopic Method for Investigating Light-absorption and the Nature of Colouring Matters. N. Umow. (Phys. Zeitschr. 18. pp. 962-971, Oct. 15, 1912.)—The method depends on "chromatic depolarisation by scattering of light." In the case of substances which show a marked absorptive power, the depolarisation of the scattered light is small for the colours which are most absorbed, and great for colours to which the scattering-surface is transparent. The extent of the depolarisation is determined by using a Savart polariscope in conjunction with a spectroscoper. The study of colour by this method has the great advantage that experiments can be made with substances which cannot be examined in solution, e.g. insoluble pigments, dyed fabrics, and natural objects. Nearly 200 illustrations are given as examples of the application of the method. T. M. L.

170. Optical Constants of Metals. C. Zakrzewski. (Acad. Sci. Cracovie, Bull. 8A. pp. 842-849, Oct., 1912.)—Starting with Kettler's formula for the phase-difference between the components, parallel and perpendicular to the plane of incidence, of the light reflected from a metal surface, the author develops mathematically formulæ giving the optical constants of the metal. These are applied to Drude's results for Ag, Ni, and Zn, and it is seen that there is good agreement between the values calculated from the formulæ and the experimental results. A. W.

171. Density and Refractive Index of Liquids in Contact. A. L. Clark. (Phil. Mag. 24. pp. 451-452, Sept., 1912.)—Chloroform which is nearly insoluble in water and has density 1.4 at ordinary temperature, has a critical density of about 0.5. The density of water at 260° (the critical temperature of chloroform) is about 0.66, so that as the temperature rises, the density of chloroform falls off more rapidly than that of water, and at one temperature they are equal. Chloroform and water were placed together in a Natterer's tube and heated in a paraffin bath. At a few degrees below the critical temperature of chloroform the equilibrium becomes unstable, and the system overturns, the chloroform rising to the top. On cooling, the chloroform sinks again to the bottom. The index of refraction of chloroform decreases more rapidly on rise of temperature than that of water. When the indices become equal the separating surface disappears from view, to reappear again when the temperature is raised still more. J. J. S.

172. Carbon Disulphide as Solvent for the Determination of the "Refraction Constant." F. Schwes. (Chem. Soc., Journ. 101. pp. 1889-1902, Oct., 1912.)—The author gives the following brief summary of conclusions drawn from an investigation of four systems: (A) In mixture with carbon disulphide, organic liquids (acids, alcohols) differ from the corresponding aqueous solutions in the following points: (1) The values observed for the density

and refraction are less than the theoretical values ; the mixtures thus undergo a dilatation, and not a contraction, as is generally the case for aqueous solutions. (2) The values $C_w/C_n = A$ (refraction constant) are much less than for the corresponding solutions in water. (8) Moreover, there is no regular proportionality between the A values in water and carbon disulphide, which shows how much A is determined by constitutive influences. (B) In spite of these differences, carbon disulphide solutions have several properties in common with aqueous solutions : (1) If we examine the solutions of carbon disulphide successively with the different terms of a series, the value of A diminishes with the increase of the molecular weight. (2) Increase of temperature produces increase of A . (8) The refraction constant diminishes from the red to the violet of the spectrum. L. H. W.

173. *Optical Properties of Substances at the Critical Point.* C. Smith. (Roy. Soc., Proc. Ser. A. 87. pp. 866-871, Oct. 2, 1912.)—The author calculates that all substances at the critical point must have the same refractive index, namely, $n_c = 1.426$ for light of infinite wave-length. Assuming that the specific refraction is constant for all temperatures, data are available for calculating the value of n_c for different substances. More data are available if the calculation is made for the D line instead of for light of infinite wave-length. From these data the critical refractive index has been calculated for 5 gases and vapours, 9 inorganic liquids and condensed gases, and 7 organic liquids. In the majority of these 21 cases "the percentage difference from the theoretical value is well within 1 %, whilst the greatest difference is only 2.2 %, but this presentation of the data includes the whole number of the refractive index, and it would be more correct to regard the errors as ranging from 10 to 22 % ; the actual values range from 1.101 to 1.146, the "theoretical" value being 1.126. A further series of eleven substances, mainly halogen compounds and aromatic substances, shows much larger deviations, the value for bromine-vapour being as high as 1.194. T. M. L.

174. *Refraction and Magnetic Rotation of Mixtures.* P. T. Muller and Mlle. V. Guerdjikoff. (Comptes Rendus, 155. pp. 774-777, Oct. 21, 1912.)—Owing to some confusion of the prisms employed, the results previously given [Abstract No. 668 (1912)] are incorrect. It is now found that with aqueous solutions of LiCl and NH_4NO_3 , the angle of rotation is practically a linear function of the refractive index, but that with mixtures of alcohol and aniline the relation is more complex. The value of $B = (\alpha/a_0)/n^2(n^2 - 1)$, where n is refractive index, α the magnetic rotation, and a_0 the rotation of an equal quantity of water, increases with the concentration for the solutions of LiCl and aniline, but decreases with the concentration of NH_4NO_3 . With the last mentioned, as also with solutions of sulphuric and acetic acids, an increase in the refractive index is in some cases accompanied by a decrease in the magnetic rotation. While the two phenomena are not necessarily independent, no general expression connecting them has yet been established. W. H. S.

175. *Optical Constants of Metals.* J. T. Littleton, Jr. (Phys. Rev. 85. pp. 806-811, Oct., 1912.)—Gives a description of the determination of the values of n , the refractive index, and k , the absorptive index, for silicon and ductile tungsten, and of the effect of heat treatments on different steels. Observations have been made by v. Wartenberg on Si and W [Abstract No. 548 (1910)], and by Ingersoll and Littleton on Si [Abstract No. 225 (1911)].

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Hagen and Rubens, also Drude, have determined k for steel, but do not give the carbon-content or previous heat treatment, so it is of interest to see whether the optical properties of the metal are affected by these two factors, which have so much influence on the physical properties of the material. Drude's method was used [Ann. d. Physik, 89, p. 481, 1890]. Observations were made at principal incidence (ϕ) and principal azimuth (ψ). Grinding was done with graded carborundum, and polishing with rouge. The results obtained for the Si used were : $n = 4.24$, $k = 0.118$, $\phi = 76^\circ 45'$, $2\psi = 6^\circ 52'$, and R (the reflecting power) = 87.8 per cent. For W the corresponding values obtained were respectively 8.46, 0.94, $78^\circ 81'$, $44^\circ 8'$, 54.5 per cent. Steels of different carbon-content and different heat-treatment were used. They are divided into four classes : I, a mixture of the segregated particles of the carbides of iron in a matrix of pure iron, obtained by keeping the metal at about 600°C. for 24 hours or longer ; II, very similar to I, the particles of the iron carbides being smaller, obtained by slow annealing from about 900°C. , or by quenching from 900°C. , reheating to about 600°C. , and holding at that temperature for 8 or 10 hours ; III, according to Campbell, a supersaturated solution of the iron carbides in α -iron, obtained by quenching from about 900°C. , reheating to about 840°C. , and holding at that temperature for 10 or more hours ; IV, quenched or hardened steel, heated to about 900°C. for 80 mins., and quenched in ice water, giving a solid solution of the iron carbides in small γ -iron crystals. A table is given of the constants of all specimens used. Classes I and II give the same values for n and k , and Classes III and IV have the same value for n , which is different from that for I and II. Hence it is concluded that the carbides of iron have some effect on the iron molecule in both the hard steel and the troostitic form, which supports Campbell's theory. The decrease in k caused by an addition of carbon is so small that a change caused by heat treatment cannot be observed. But the changes in n caused by changes in the carbon-content and by heat treatments are quite large. Hence lack of similarity in these two factors would account for any lack of agreement between measurements of the optical constants of steels of unknown compositions and heat treatments. A. W.

176. *General Theory of Images.* M. Wolfke. (Ann. d. Physik, 89, 8, pp. 569-610, Oct. 15, 1912.)—Gives a general mathematical theory of the formation of images of objects self-luminous (*selbstleuchtender*) and non-self-luminous. The results of the theory are then tested experimentally, and some are found in conflict with the theory of Abbe but in harmony with the author's theory. [See Abstracts Nos. 228 and 1475 (1911).] E. H. B.

177. *Perception of Lights of Short Duration at their Range Limits.* A. Blondel and J. Rey. (Amer. Illum. Engin. Soc., Trans. 7, pp. 625-658 ; Discussion, pp. 658-662, Nov., 1912.)—A more complete account of the work dealt with in Abstract No. 1476 (1911).

178. *Trichromatic Theory of Colour Vision—the Measurement of Retinal Fatigue.* W. de W. Abney. (Roy. Soc., Proc. Ser. A. 87, pp. 415-427, Oct. 81, 1912.)

179. *Translation Series in Line Spectra.* T. van Lohuizen. (Konink. Akad. Wetensch. Amsterdam, Proc. 15, pp. 156-165, Sept. 8, 1912.)—In a VOL XVI.—A.—1918.

previous paper the author showed how he had discovered series in the spectra of Sn and Sb by using a model based on a certain fundamental principle [see Abstract No. 1698 (1912)]. In the present paper it is shown how the same idea may be utilised in arranging the series of systems of the different elements in better order. A great deal has already been done in this direction by Rydberg, Kayser and Runge, and others, and particularly by using the "combination principle" of Ritz. But Mogendorff [Abstract No. 812 (1912)] has shown that Ritz's arrangement is not the only one, as most of the combinations are indicated as summational and differential vibrations. Hicks distinguishes four kinds of "sequences": (1) Principal (P) sequence, (2) Sharp (S) sequence, (3) Diffuse (D) sequence, (4) Fundamental (F) sequence. In connection with these it may be seen that when we confine ourselves to one component, all the series and combinations are formed from these four sequences. All the series and combinations may be graphically represented by one and the same curve, which is subjected to four different rotations with regard to the original system of axes. All the series that are represented by curves of equal rotation belong to one group, and differ only in asymptote. They may be changed into each other by a translation of the curve parallel to the y -axis. The author thus calls them *translation series*. The asymptotes may be found from a curve with the same or with another rotation. So every spectral line is determined by its number on the curve and by the asymptote of this curve. It is suggested that a uniform notation be adopted. The different series are denoted by Px , Sx , Dx , Fx , where $x = 1, 2, 8, \dots$. The form of these series is somewhat different for the different spectral formulæ, but yet there is close agreement. The numerators are the same for all three (Ritz, Mogendorff-Hicks, v. Lohuizen), the universal constant 109675.0. The roots from the denominators contain three terms: the parameter (m or x), a constant (a , p , s , d , or μ), and the coefficient of the third term (b , π , σ , δ , or γ). It is suggested that the following symbols be adopted: x , (p , s , d , f), (π , σ , δ , ϕ). Thus v. Lohuizen's formulæ would be $Px = 109675.0/(x + p + \pi y)^2$, $Sx = 109675.0/(x + s + \sigma y)^2$, etc., where x may be 1, 2, 8, ... Ritz's notation for the second subordinate series $x = 1.5, 2.5, 8.5, \dots$ is discarded, v. Lohuizen agreeing with Hicks's view in this respect. It may be noticed that in Fx , f differs very little from a whole number, and ϕ becomes practically zero. So the denominators differ little from 8^2 , 4^2 , etc. Then, using the principle that, in accordance with Ritz's theory, every spectral line is brought about by the difference of two actions, the designation of every spectral line is evident. We must state of what two terms of what two series its frequency is the difference. So the second line, for instance, of the principal series is represented by $S_1 - P_2$, the whole principal series by $S_1 - Px$. Omitting the negative sign for simplicity, we write S_1P_2 and S_1Px for these respectively. *A priori* the following series are possible:—

I.	II.	III.	IV.
$Pz \quad Px$	$Pz \quad Sx$	$Pz \quad Dx$	$Pz \quad Fx$
$Sz \quad Px$	$Sz \quad Sx$	$Sz \quad Dx$	$Sz \quad Fx$
$Dz \quad Px$	$Dz \quad Sx$	$Dz \quad Dx$	$Dz \quad Fx$
$Fz \quad Px$	$Fz \quad Sx$	$Fz \quad Dx$	$Fz \quad Fx$

Up to now only one or more lines have been observed of the series in lead type. The series in column I are *Principal Series*. They form together a
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group of Translation Series and differ only in asymptote. The above views are illustrated from the sodium series ; a plate is given showing the different curves, all drawn from the same template, constructed with special care. The diagram throws light on the so-called summational and differential series discussed by Mogendorff and also on the combination principle of Ritz. It also appears that the principle of continuity would lead to the introduction of negative frequencies.

A. W.

180. Reflection of Röntgen Radiation. C. G. Barkla and G. H. Martyn. (*Nature*, 90. p. 435, Dec. 19, 1912.)—Following the investigations of Laue, Friedrich, and Knipping, the authors studied the transmission of a narrow pencil of Röntgen-rays through rock-salt, a crystal of simple cubic form. The results showed a strong reflection from the internal crystallographic planes upon which the pencil fell at nearly grazing incidence. The pencil so reflected is of such intensity that the short exposure required to produce well-marked effects on a photographic plate is insufficient to give more than a trace of the most intense of the other pencils of radiation emerging from the crystal. The angle turned through by the reflected beam was within a very small possible error, the same as that turned through by the incident pencil. A small cleaved fragment of crystal was placed with one pair of faces horizontal, and a narrow pencil of Röntgen-rays was directed on the under surface in one of the three principal planes of the crystal. When the pencil of rays made a slight angle with the normal to the surface, the pencil was directed at nearly grazing incidence on one of the sets of vertical principal planes in the crystal. The result was a well-marked spot on the photographic plate situated several cm. above the crystal, on the same side of these crystallographic planes as the incident pencil. The effect was also observed on the other side of the normal. The results can be accounted for by the reflection from a large number of layers of atoms, parallel to one of the pairs of faces of the crystal.

A. W.

181. Absorption and Reflection of Homogeneous β -Particles. W. Wilson. (*Roy. Soc., Proc. Ser. A.* 87. pp. 310-325, Oct. 2, 1912.)—By means of a magnetic field a homogeneous pencil was separated out from the β -rays emitted from a source of radium in equilibrium [see Abstract No. 1488 (1910)]. The β -rays transmitted through various foils were measured in a hemispherical ionisation chamber and curves obtained representing the absorption of homogeneous β -rays of various velocities by Al, Sn, and Cu. The results show that β -ray beams of high velocity can penetrate considerable quantities of matter (0.5 mm. Al) without appreciable reduction in intensity as measured by ionisation. The fact that β -rays, initially homogeneous, are absorbed by Al according to an exponential law after passing through a small thickness of Pt is confirmed by the experiments [see Crowther, Abstract No. 1607 (1910)], and this is shown not to be due to mere scattering of the rays, but to the fact that the beam is rendered heterogeneous in its passage through the Pt. It appears that on the passage of a homogeneous beam of β -rays through matter, some of the particles undergo more violent encounters with the atoms they traverse than others, and there is therefore a tendency for the beam to become heterogeneous. This proceeds until a definite state of equilibrium is reached, when the further passage of the beam through matter produces no further change in its properties, and the beam is then absorbed according to an exponential law. In such a beam the distribution of numbers of the particles composing

it with respect to velocity would not alter as it penetrated matter, the greater absorption of the particles of lower velocity being compensated by the decrease in velocity of a portion of the more rapid rays.

The author has also studied the reflection of homogeneous β -rays, and it is shown that the slow rays reflected when β -rays of UrX fall on matter [see Abstract No. 82 (1918)] are due to reflection of the slower portion of the primary beam. From the results it is deduced that there is no necessity to assume the existence of a real secondary when β -rays strike matter. E. M.

182. Scattering and Absorption of β - and Röntgen-Rays in Crystals. J. Stark. (Phys. Zeitschr. 18. pp. 978-977, Oct. 15, 1912.)—Previous experiments of the author have shown that canal rays penetrate further along special parallel planes of a crystal than along others [Abstract No. 1868 (1912)]. Developing this idea the author takes the view that in crystals the atoms are all arranged regularly so that parallel straight lines can be drawn passing through practically no atoms. With β -rays incident in such directions there will be abnormally little absorption, and adopting a corpuscular hypothesis the same will be true of X-rays. Similarly with β - or X-rays incident on a crystal we should expect certain peculiarities of scattering along these directions. The author claims that the general results of Friedrich and Knipping [K. Bayer. Akad. München, Ber. p. 808, 1912] can be as well explained on this hypothesis as on that of Laue. In these experiments a narrow beam of X-rays was directed on to a crystal plate of ZnS and regularly distributed spots were found to be produced on a photographic plate placed beyond the ZnS. Thus: (1) The size of the spots on the photographic plate is independent of its distance from the ZnS. (2) With thicker plates there is a greater intensity of the spots. (3) The positions of the spots are independent of the hardness of the X-ray bulb since they depend only on the "channels" in the crystals. (4) The spots are elliptical in shape, etc.

E. M.

183. Units of Quantity of Radium Emanation. J. and G. Danne. (Archives d'Él Médicale, 20. pp. 521-527, Dec. 10, 1912. Paper read before the Assoc. franç. pour l'Avancement des Sciences, Nîmes, Aug., 1912.)—The International Congress at Brussels in 1910 decided on a unit for RaEm, this unit being the amount of emanation in equilibrium with 1 gm. Ra and being defined as a "curie." [More convenient practical units for some purposes are the millicurie and the microcurie, equal to 10^{-3} and 10^{-6} curie respectively. In terms of the older units 1 curie = 4.80×10^6 gm. seconds or 2.5×10^9 Mache units. [The gm. second is the amount of emanation produced by 1 gm. Ra per sec. The Mache unit is the quantity of RaEm without disintegration products which produces a saturation current of 10^{-8} e.s. unit in a chamber of large dimensions.] Such units as volt-hour, etc., which have often been used have no meaning apart from the capacity of the particular instrument employed.

E. M.

184. Velocity of δ -Rays. F. Hauser. (Phys. Zeitschr. 18. pp. 986-940, Oct. 1, 1912.)—Previous experiments of the author [Abstract No. 1501 (1911)] have been criticised by Campbell [Abstract No. 1086 (1912)], who affirms that from measurements of the p.d. between two electrodes on one of which α -particles are falling, very little information can be obtained as to the velocity of the secondary δ -rays. Campbell's objection arises partly from the fact that a very large field is required to completely drag out the

negatively-charged δ -rays from a plate. In the present experiments the author shows that this effect is only pronounced when dealing with rough surfaces such as carbon or soot. With smooth surfaces, using polonium, practically all the δ -rays come out without a field, whether from the plate on which the polonium is deposited or from an electrode on which the α -particles are falling. The velocity distribution of the δ -rays was determined from the values of the potential required to prevent their escape from a plate, and found to be about that of Maxwell for the distribution of the velocities of the molecules in a gas. However, from a "poloniumised" plate δ -rays could be detected with velocities up to the values corresponding to a fall of potential of from 88 to 48 volts, while from an electrode on which the α -particles fell, the max. velocities detected corresponded to only 15–20 volts. Higher velocities were presumably not observed in both cases owing to the small number of particles to be expected. The mean velocity of the secondary δ -rays was determined to be from 4 to 10 volts, the more frequently occurring having velocities not greater than 6 volts. E. M.

185. *Radio-activity of Water issuing from Monte Amiata, and Atmospheric Dispersion in the Neighbourhood.* R. Nasini and C. Porlezza. (Accad. Lincei, Atti, 21. pp. 476–478, Oct. 27, 1912.)—A redetermination of the radio-activity of the water from several springs on Monte Amiata some twelve months after the first examination [Abstract No. 1210 (1912)], and following an unusually dry period, gives results very similar, with one exception, to those previously obtained, and shows this property of the waters to be fairly constant. The atmospheric dispersion was also not appreciably different. W. H. St.

186. *Estimation of Emanation Content of Spring Waters.* G. Berndt. (Ann. d. Physik, 88. 5. pp. 958–986, Aug. 18, 1912.)—The paper is theoretical and deals with a calculation of corrections necessary for the time since the water was collected, etc. Following the results of Duane and Laborde [Abstract No. 926 (1910)] the author concludes that in terms of the initial and max. α -ray activity of RaEm enclosed in a cylindrical ionisation vessel of internal area O , and volume V (at 760 cm. and 15° C.), 1 Mache unit is equal to $\lambda/1000 \times 5.2(1-0.52 O/V)$ and $\lambda/1000 \times 18.15(1-0.52 O/V)$ respectively; λ being the disintegration constant of RaEm, i.e. 2.08×10^{-6} . E. M.

187. *Fluctuations in the Ionisation Produced by γ -Rays.* E. Buchwald. (Ann. d. Physik, 89. 1. pp. 41–52, Sept. 5, 1912.)—The author, continuing the work of E. Meyer and others, has made a mathematical investigation of the variations produced in the ionisation from a constant source of γ -rays. E. M.

188. *The Discovery of Radio-activity, and its Influence on the Course of Physical Science.* O. Lodge. (Chem. Soc., Journ. 101. pp. 2005–2042, Oct., 1912. Becquerel Memorial Lecture.)

189. *Emanation from the Soil to the Atmosphere.* L. B. Smyth. (Phil. Mag. 24. pp. 682–687, Oct., 1912.)

HEAT.

190. *Thermostat with Air-heating.* F. Göpel. (Zeitschr. Instrumentenk., Beib. 20. pp. 209-211, Oct. 15, 1912. Communication from the Physikal.-Techn. Reichsanstalt.)—Describes a large thermostat, the inside space having a base area of 50×75 cm.², and height 80 cm. The inner walls are of sheet copper and the outer of sheet zinc. The base of the outer case is continuous, but the base of the inner case has a space 25 mm. in width between it and the sides. The double-walled space is closed at the top by a strong glass plate, 5 cm. below which is another provided with a rectangular opening. The walls between the two glass plates are provided with holes. The heating of the circulating air is effected by means of a flat ring-shaped coil, electrically heated, over which the air must pass. The thermostat has an outside casing, which gives outside the zinc case an air-space, then a layer of cork, then another air-space, and last the outer cover of wood. Temperature researches show that inside the thermostat the temperature can without difficulty be maintained constant to 0.1 deg. Two cooling experiments (after stopping the motor for the heating) gave for 4 deg. temperature-difference between the room and the thermostat a cooling of 0.018 deg. per min., for 6 deg. temperature-difference a cooling of 0.021 deg. per min. For further details the diagrams in original paper should be consulted. A. W.

191. *Dilatation of Steel.* W. Block. (Kaiserl. Normal-Eichungs Kommission, Wiss. Abhandl. No. 8. pp. 59-69, 1912.)—By means of the Fizeau interference dilatometer, used with helium lines, the dilatation of hardened and tempered samples of steel in ranges of 40 deg. or 80 deg. were in one instance $(12.01 + 0.0110T) \mu$, and in another $(12.96 + 0.0168T) \mu$. The mean value gives 12.76μ at 20°. Three unhardened samples of the same steel gave the following results :—

$$\begin{aligned} &(10.06 + 0.0186T) \mu \text{ per metre.} \\ &(10.51 + 0.0091T) \mu \quad " \\ &(10.28 + 0.0115T) \mu \quad " \\ &\text{Mean } (10.28 + 0.011T) \mu \quad " \end{aligned}$$

and, at 20°, 10.50μ per metre. Attention is drawn to the marked difference between the hardened and unhardened samples. The effect is, however, more marked in a small sample, because the hardening is more complete. The following values are suggested for use, as being correct to about 2 % :—For pieces with dimensions about 100 mm., 11μ ; 50-20 mm., 11.5μ ; 20-10 mm., 12μ ; 10 mm. and less, 12.8μ . F. R.

192. *Apparatus for Boyle's Law.* P. Gehne. (Phys. Zeitschr. 18. pp. 946-948, Oct. 1, 1912.)—Describes a small apparatus for the demonstration of Boyle's law, and adapted for projection with an ordinary lantern. A horizontal capillary glass-tube (C) has a small air-bubble at the closed end; the other end is connected to a manometer tube (M), and a side connection from M leads to a longer vertical tube (V). M is completely filled with mercury at first, V being about one-third full, and the apparatus is then evacuated, and the top of V sealed. V contains also a glass rod, to the upper

end of which a short iron cylinder is attached. The pole-pieces of an electro-magnet fit round the tube V, and so by raising or lowering the magnet the glass rod may be moved to any desired position inside the tube, thus giving a ready means of altering the level of the mercury inside. The pressure of the air-bubble in C is measured by the height of the mercury in M above the horizontal tube C, and the volume is determined by the length of tube filled. Both the tubes C and M are provided with appropriate glass scales, and these are shown on projection, so that Boyle's law may be easily demonstrated to a class. In addition, a thin wire, bent into the proper hyperbola curve for the apparatus, and fixed relative to two axes, also of wire, is adjusted so that the end of the mercury thread in C lies on the curve, while the horizontal axis coincides with the level of the mercury in M. The curve with its axes is connected by a string passing over two pulleys to the movable electro-magnet, and as the latter moves up or down the horizontal axis moves down or up, and thus always coincides with the level of the mercury in M. As the wires are projected with the rest of the apparatus, it is easy to see how the end of the mercury thread in C always lies on the curve. A. W.

193. Dilatation of Solids. W. Block. (Kaiserl. Normal-Eichungs Kommission, Wiss. Abhandl. No. 8. pp. 78-84, 1912.)—The difference between the expansions of a rod of known dilatation and the specimen is measured by attaching a knife-edge to one end of the standard rod, and resting one end of the specimen on this. Between the other ends is supported a double knife-edge carrying a mirror, whose movements are observed in the usual way. The results for three samples of galvanised iron telegraph wire per 1 deg. C., per metre at 18° C., ranged from 11.65 μ to 11.78 μ , including strained specimens. A mean result for two samples of ebonite was 94 μ per 1 deg. C. per m. at 20°. An Al alloy containing, besides Al, chiefly Cu 7.28 and Zn 2.9 per cent., gave 22.7 μ at 26° C. Another with 4.98 per cent. Cu gave 23.1 μ at 25.5°. Another with 4.88 Cu, 0.72 Mn, 0.58 Mg gave 22.5 μ at 25.5°. These results are slightly lower than the figure 23.5 μ usually given for Al.

F. R.

194. Rise of Temperature near Melting Icebergs. H. T. Barnes. (Engineering, 94. pp. 809-810, Dec. 13, 1912. Nature, 90. pp. 408-410, Dec. 12, 1912.)—The author withdraws certain statements made in his Royal Institution lecture [Abstract No. 1010 (1912)]. Taking measurements in the Straits of Belle Isle, he finds that the temperatures of the water decreased as the distance from the iceberg increased, e.g. from 5.2° to 3.3° C. in a distance of 5 miles. With the assistance of McIntosh and O. Maass he also observed that the density of the water near the iceberg was not appreciably diminished by the melting ice, because the bergs melted slowly. He therefore adheres only to the first two of O. Pettersson's three suggestions, which he had previously supported: The melting of ice in salt water produces three currents: (1) a current of sea water cooled by the ice, sinking downward; (2) a current of warm water moving towards the ice; (3) a current of light fresh water from the ice, rising and spreading over the surface of the sea. The white colour of icebergs, he further states, is due to air bubbles, which makes the melting ice effervesce in experiments, and may account for the explosion of icebergs; the cooling effect produced by land is confirmed. H. B.

195. Specific Heat of some Elements at Low Temperatures. T. Estreicher and M. Staniewski. (Acad. Sci. Cracovie, Bull. 8a. pp. 884-841, Oct., VOL. XVI.—A.—1918.

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1912.)—The method of mixtures was used, the element of which the specific heat was to be determined, being cooled to -190° in liquid air, or to -80° in solid CO_2 and alcohol, and then introduced into water or toluene in the calorimeter. In the case of bromine and iodine the elements were sealed up in glass bulbs, whereas with sodium and potassium cylinders of the pure metals were wrapped tightly in tin-foil, whereby oxidation was prevented. The following specific heats were obtained, the temperature range being indicated in brackets: Toluene, 0.4015 ± 0.0008 (14° – 17.5°); bromine, 0.07016 (-192° to -80°), the atomic heat being 5.61 ; iodine, 0.0454 (-191° to -80°) and atomic heat, 5.76 , 0.04852 (-90° to $+17^{\circ}$), atomic heat, 6.16 ; sodium, 0.2478 (-191° to -80°), the atomic heat being 5.70 , 0.2714 (-80° to $+17^{\circ}$), atomic heat, 6.24 ; potassium, 0.1551 (-191° to -80°) and atomic heat, 6.06 , 0.16771 (-80° to $+18^{\circ}$), atomic heat, 6.56 ; manganese, 0.06208 (-188° to -79.2°), atomic heat, 4.505 , 0.10906 (-79.2° to $+15^{\circ}$), atomic heat, 5.99 .

T. S. P.

196. *Radiation Constant.* L. Puccianti. (N. Cimento, 4. Ser. 6. pp. 822–880, Oct., 1912.)—The author has made a further determination of the radiation constant of a black body, neutralising the heat lost by one black body at the ordinary temperature to another black body at the temperature of liquid air by the Joule effect of an electric current, and determining directly the p.d. and the resistance of the conductor. The method is not so sensitive as the bolometric one previously described [Abstract No. 1858 (1912)], but the value of σ is found to lie between 6.00 and 6.80×10^{-12} . W. H. St.

197. *Denial of Kirchhoff's Law for Heterogeneous Bodies.* W. Voigt. (Phys. Zeitschr. 18. pp. 848–852, Sept. 15, 1912.)—A mathematical discussion of the proportionality of emission and absorption, in which it is maintained that this proportionality (asserted by Kirchhoff) has only so far been established for homogeneous bodies. [See Abstracts Nos. 551 (1910) and 1868 (1912).] E. H. B.

198. *Determinations of the Vapour Tension of Nitrogen Tetroxide.* F. E. C. Scheffer and J. P. Treub. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 166–178, Sept. 8, 1912.)—The critical temperature of nitrogen tetroxide, observed by reflected light in a paraffin bath, is found to be 158.2° . The vapour tension has been observed in a manometer similar to that used previously [compare Abstract No. 518 (1912)], but more elongated and smaller. In one form of the apparatus the manometer is enclosed in a combustion tube attached to a Cailletet apparatus and provided with an outer jacket containing liquid, which may be heated electrically. The highest pressure thus obtainable is 67 atmos., which is below the critical pressure. In a second form of apparatus the combustion tube is replaced by a copper tube, provided with transverse tubes opposite the needle of the manometer, closed with glass plates cemented into steel mounts by an enamel of sodium and potassium carbonates, lead oxide and silica. The copper tube is surrounded by two spiral lead tubes, through which heated oil is circulated in opposite directions. A pressure of 150 atmos. may be reached. The critical pressure is 100 ± 2 atmos. Calculation shows that at the critical point the substance must consist almost entirely of NO_2 -molecules. The calculated heat of evaporation at the boiling-point is 9200 gm. cals.

T. S. P.

SOUND.

199. Axial Emission of Sound in a Cylindrical Tube. M(ary) Taylor. (Phil. Mag. 24. pp. 655-664, Oct., 1912.)—A mathematical treatment of a problem suggested by Rayleigh's "Sound" (art. 801). The result is obtained that, in the absence of dissipative forces, the emission of energy by the source is a *discontinuous* function of the frequency. If the frequency is gradually increased, the emission tends to become infinite as the frequency approaches any one of a series of critical values, but becomes finite again *immediately* on passing these. An attempt is made to show the manner in which dissipative forces will affect the above results. E. H. B.

200. Maintenance of Vibrations by Variable Spring. C. V. Raman. (Phil. Mag. 24. pp. 513-520, Oct., 1912.)—This paper deals with the maintenance of vibrations by a periodic variation of the spring to which the system is subject. The matter is treated analytically, and it is shown that with the relations of frequencies contemplated the energy supplied compensates for that dissipated. The maintenance in question is then experimentally realised, and fifteen photographs show the figures obtained by a point on a string maintained in vibration by a fork on the principle of Melde's experiment. The relation referred to is illustrated as follows: If the frequency of the imposed variation of spring is 60 per sec., then, under suitable circumstances, vibrations would be maintained on systems whose free periods are nearly equal to 80, 60, 90, 120, 160, etc. E. H. B.

201. Photography of Sound-waves. A. L. Foley and W. H. Souder. (Phys. Rev. 35. pp. 873-886, Nov., 1912.)—Describes the photograph of the sound-waves from an electric spark by a point source shadow method very similar to that used by C. V. Boys in 1892 for the photography of "flying" bullets and their accompanying shells of compressed and rarefied air. Thirty excellent reproductions of the photographs accompany the paper. These include plane and spherical reflection, spherical refraction at lenses of SO₂ and CO₂, and diffraction at plane and curved gratings. E. H. B.

202. Upper Partial of Tuning-fork. F. H. Parker. (Nature, 90. p. 861, Nov. 28, 1912.)—Calls attention to the use of the fall plate to obtain on its smoked surface traces of the fundamental and upper partials of a tuning-fork, and thus ascertain their frequency ratios. Smoke traces were taken and a reproduction is given. The prime had a frequency of 29.5, and the upper partials were theoretically expected to have frequencies of the order 185 and 510, while the experimental numbers from single observations of each were 184 and 512 respectively. E. H. B.

203. Exhibition of Phonographic Waves. H. Benndorf and R. Pösch. (Akad. Wiss. Wien, Ber. 120. 2a. pp. 1811-1882, Dec., 1911. 24th Report of the Phonogramm-Archivs-Kommission.)—Describes an apparatus for making traces of the waves in a phonograph plate. A needle passes between two pairs of rollers to feel the waves and its motion is magnified by two levers whose arms are 5 to 100 mm. and 6 to 400 mm. respectively. [See Abstract No. 257 (1909).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

204. *Magnetic Force on Moving Electrons.* L. de la Rive. (Archives des Sciences, 84. pp. 266-267, Sept., 1912. Paper read before the Soc. Suisse de Physique, Altdorf, Sept. 10, 1912.)—A new mathematical treatment of the motion of an electron in a magnetic field. Its result is summarised as follows:—"The identity of the Biot-Savart force with the composite centrifugal force, which in the case of negative charges are contrary in direction, produces in the case of rotating axes the disappearance of the centrifugal force and the appearance of an attractive force proportional to the distance."

E. E. F.

205. *Model of a Radiating Atom.* K. F. Herzfeld. (Akad. Wiss. Wien, Ber. 121. 2A. pp. 598-601, April, 1912.)—Thomson's positive atom is modified so as not to contain the same density of positive electrification throughout, but a density varying at various depths. The electrons revolve in concentric circles only. It is then shown that a model may be obtained which emits Balmer's series of hydrogen lines.

E. E. F.

206. *Multiply-charged Atoms.* J. J. Thomson. (Phil. Mag. 24. pp. 668-672, Oct., 1912. Paper read before the Mathematical Congress, Cambridge, Aug., 1912.)—In the photographs of the positive rays the Hg line is remarkable for the exceptionally small displacement of the head of its parabola [see Abstract No. 1870 (1912)]. Even when the electric and magnetic fields are strong enough to produce deflections of several mm. in the heads of the parabolas corresponding to the other elements, the head of the Hg parabola is so little deflected that it seems at first to coincide with the origin. When, however, the electric field is very large (from 5000 to 10,000 volts per cm.) the head of this parabola is found to be displaced by $\frac{1}{4}$ of the normal displacement of the heads of the parabolas corresponding to the other elements. The displacement due to the electric field is inversely proportional to the kinetic energy of the particle displaced, so that the atoms which produce the head of the Hg parabola must have 8 times the max. amount of energy possessed by the normal atoms. This could be accounted for if some of the Hg atoms in the discharge tube had lost 8 corpuscles. The plates taken with large electrostatic deflections show the existence of 7 parabolas due to Hg; the eighth has not been detected, but as the parabolas get in general fainter for each additional charge on the atom, the parabola corresponding to 8 charges is probably too faint to be detected. The question arises as to how the Hg atom acquires these very various charges. Reasons are given, based on examination of the photographs, for believing that there is no ionisation of such a kind as to deprive the Hg atom of 7, 6, 5, 4, 3, or 2 corpuscles, but that there are only two types of ionisation. In the first method the ionising agents are the rapidly moving corpuscles which constitute the cathode rays; these very small particles penetrate into the atom and come into collision with the corpuscles inside it individually, the collision in favourable cases causing the corpuscle struck to escape from

the atom ; this type of ionisation results in the atom losing a single charge. In the other type of ionisation we suppose that the Hg atom is struck by a rapidly moving atom and not by a corpuscle ; after the collision the Hg atom starts off with a very considerable velocity, which at first is not shared by the corpuscles inside it. Thus if there were 8 corpuscles in the Hg atom connected with about the same firmness to the atom, the result of the atom acquiring a high velocity by collision might be the detachment of the set of 8, leaving the atom with a charge of 8 units of positive electricity. The atoms with from 2 to 7 units of positive electricity must be supposed to have regained 6 to 1 corpuscles subsequently. All the elements examined give multiply-charged positive atoms with the exception of hydrogen, on which never more than one charge has been observed. The majority of the elements seem to acquire only two charges. Nitrogen atoms have been observed with 8 charges, but the parabola due to the triply-charged atom is exceedingly faint. Argon shows triply-charged atoms very distinctly. The argon plate shows the He line, and from this it is concluded that in a volume of about 2 litres of argon at 1/800 mm. Hg pressure a quantity of He occupying only 4×10^{-6} c.cm. at atmospheric pressure could be detected. An interesting result, which is being further investigated, is that when very pure nitrogen is in the discharge-tube the Hg line corresponding to the atom with 5 charges becomes abnormally bright, brighter than those for the atom with 4 or even 8 charges, though in other gases the greater the charge the fainter the line.

A. W.

207. Atomic and Molecular Charges. F. Sanford. (Phys. Rev. 85. pp. 276-281, Oct., 1912.)—Forms estimates of the atomic and molecular charges from the work of J. J. Thomson and of Knipp, and thus shows that for a number of Li-, Na-, and K-salts the relations (i) between heat of formation and molecular charge, and (ii) between solubility and charge are each linear. Hence the same law holds between the heat and the solubility.

E. H. B.

208. Coefficients of the Lorentz Transformation. C. Kraft. (Acad. Sci. Cracovie, Bull. 5a. pp. 385-415, May, 1912.)—Calculates the coefficients for the case when the two systems of co-ordinates have no common axis, but are inclined to one another at any angle. The treatment is based on the relativity principle.

E. E. F.

209. Unipolar Induction and Condenser Rotating in Magnetic Field. E. H. Kennard. (Phys. Zeitschr. 18. pp. 1155-1157, Dec. 1, 1912.)—The author's conclusions [see Abstract No. 1859 (1912)] having been contested by Barnett, the matter is treated analytically, and the author considers that the experiments of Barnett and himself support the view that in unipolar induction the e.m.f. has its seat in the moving part, whichever this may be, and that they contradict the simplest form of the theory of moving lines of force.

G. E. A.

210. Electromagnetic Induction and Relative Motion. S. J. Barnett. (Phys. Zeitschr. 18. pp. 808-805, Sept. 1, 1912. Phys. Rev. 85. pp. 828-886, Nov., 1912.)—A cylindrical condenser, short-circuited by a wire, brought into a uniform magnetic field parallel to the axis of the condenser, and rotated round its axis while the magnet (or coil) remains fixed in position, becomes charged to a certain voltage ; this voltage is equal to the product of the angular velocity into the magnetic flux through the annular space

between the two condenser plates. If, on the other hand, the condenser and its appurtenances are fixed while the magnet (or coil) is rotated, the relative movement is the same, but the question remained whether the condenser becomes charged to the same extent as before. The author's results give a decided answer in the negative, the resultant charge being, within the limits of error, equal to zero. Then follows a discussion of the history of the question and of its bearings on the problem of unipolar induction. This problem cannot be solved by experiments on closed circuits or by any of the electrostatic methods hitherto proposed.

A. D.

211. Changes in Dielectric Constant by Strain. E. P. Adams and C. W. Heaps. (Phil. Mag. 24. pp. 507-518, Oct., 1912.)—One of the present authors previously obtained the following expression for the fractional elongation of a charged thin cylindrical condenser, open at the ends, $e = - (V/d)^2 (\delta_1 + \delta_2) \sigma / K$, where d is the thickness of the dielectric and is small compared with its internal radius, V is the p.d. to which the condenser is charged, σ is Poisson's ratio, and K the specific inductive capacity of the dielectric; δ_1 and δ_2 are two constants of the dielectric: the former the change in K for unit strain along the lines of force, and the latter for unit strain in a perpendicular direction [see Abstract No. 528 (1912)]. The present paper deals with experimental determinations of the deltas for hard rubber, soda glass, and Jena glass. It is found that for these solid dielectrics (as for fluid dielectrics) the two deltas are practically equal. The values are then as follows:—

Dielectric.	Hard Rubber.	Soda Glass.	Jena Glass.
Value of $(\delta_1 + \delta_2)$	— 2.56	— 8.14	— 8.4

On the erroneous theory of electrostriction the elongation to be expected is given by $e' = (V/d)^2 K / 8\pi E$. The ratio of the two expressions for elongation is $e/e' = - (\delta_1 + \delta_2) \sigma / K$. For the soda glass and Jena glass the values of this ratio are of the order 0.07 and 0.25 respectively.

E. H. B.

212. Electrification by Liquid Dropping. K. v. Bernolák. (Ann. d. Physik, 89. 8. pp. 497-518, Oct. 15, 1912.)—An experimental research from which the following conclusions are drawn:—(1) The phenomena of electrification by the separation of liquid drops at a pipe end (noticed by Holmgren and later by Trübi) was confirmed under most rigorous conditions. (2) The magnitude of this effect depends essentially on the type of the drop formation, and is not fixed simply by that of the primary drops. (3) The electrification depends largely on the formation of the smaller or secondary drops which occur between the primary ones. (4) The magnitude of the electrification depends on the number and speed of formation of these secondary drops (or droplets). (5) When the sudden development of these droplets is hindered the electrification may be diminished by 80-80 per cent.

E. H. B.

213. The Large Ions in the Atmosphere. J. A. McClelland and H. Kennedy. (Roy. Irish Acad., Proc. 80. 5. pp. 72-91, Dec., 1912.)—For the purpose of the experiments a special apparatus was constructed to the authors' design, and attention was first directed to the question of whether the large ions are all of the same mobility or whether they are a mixture of ions of different masses. The former was found to be the case, and the value for the mobility, 1/3100 cm. per sec., is in good agreement with that given by Langevin. No indication was found of ions of a mobility of 1/100 cm.

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per sec. as found by Pollock. Assuming that each ion carries the electronic charge the number of large ions per c.cm. was found to vary from 8700 to 60,000, the average number being 16,000. There was no difference between the number of positive and negative ions. Some experiments were made on the power of reproduction of large ions in air which has been previously freed from them. As regards the nature of the ions the conclusion is reached that they consist of invisible water drops which have combined each with one small ion. The probable capture of large ions by the type of apparatus commonly employed to measure the number of small ions present in the atmosphere throws great doubt on the accuracy of the figures usually given for this number. It is pointed out that the observations recorded in the paper were all made in impure town air.

J. S. DI.

214. *Electric Screening by Silver Films.* [Miss] S. Hyatt. (Phys. Rev. 35. pp. 337-346, Nov., 1912.)—By experiments on an electroscope inside a cage having a hole at the top covered by a glass plate bearing a silver deposit on one side, it was found that at some limiting thickness between 30 to 50 $\mu\mu$ a silver film when used as part of a hollow conductor becomes opaque to electrostatic induction from outside.

E. H. B.

DISCHARGE AND OSCILLATIONS.

215. *Effect of a Magnetic Force on the Motion of Negative Ions in a Gas.* J. S. Townsend and H. T. Tizard. (Roy. Soc., Proc. Ser. A. 87. pp. 367-365, Oct. 2, 1912.)—When the velocity of an ion in a gas is proportional to the electric force (X) and inversely proportional to the pressure (P) the size of the ion is unaltered by changes in either. For a large range of pressures this condition holds, but for low pressures the velocity of the negative ions undergoes large changes when small variations are made in either X or P. The increase in mobility may be explained on the hypothesis that the mass associated with the negative ion diminishes at low pressures. The present experiments were made to investigate this, and to find to what extent the electrometric state prevails as the pressure is reduced. A stream of negative ions moving with a constant velocity under a small electric force was obtained by allowing them to pass through a slit into the electric field. The stream fell on a system of parallel electrodes, and could be deflected by a small magnetic field (about 14 e.m. units). From considerations of disturbances by diffusion the experiments were generally carried out at pressures from 8 to 10 mm. of Hg. The mean value of e/m for the ions in the stream was deduced from the amount of deflection caused by the magnetic field. Even at the higher pressures the results showed that the electrons cannot be associated with the molecules continuously. With a force of 2 volts/cm. and a pressure of 88 mm. Hg the mean value of e/m was found to be 4×10^{17} . The value of e/m when m is a molecule of air is 10^{13} , and for an electron it is approximately 5.6×10^{17} . This shows that under these circumstances of pressure and electric field (with dry air) the ion must be in the electronic state while travelling between most of the collisions with molecules. Further investigations are in progress at lower pressures and with higher electric forces.

E. M.

216. *Kinetic Theory of Ionised Gases.* Gouy. (Comptes Rendus, 155. pp. 683-686, Oct. 14, 1912.)—Considers a gas maintained adiabatically at a VOL. XVI.—A.—1913.

temperature such that a very small portion of its molecules are dissociated into ions. Shows that if the gas is contained in a magnetic field, this field, together with gravitation, impresses upon the ions a motion normal to both fields, which is in opposite directions for the positive and negative ions respectively. This motion is only annulled by collisions if the gas is dense. The movements are co-ordinated, which is not the rule in thermal agitation. If two opposite walls were metallic plates joined by a wire, a continuous current could be maintained in them by means of a permanent magnetic field, which plays the part of Maxwell's "demon." Probably Carnot's principle must be considered to fail in this case. E. E. F.

217. *Diffusion of Ions into Gases at Low Pressure.* C. E. Haselfoot. (Roy. Soc., Proc. Ser. A. 87. pp. 850-857, Oct. 2, 1912.)—Townsend has previously determined the charges on ions produced by Röntgen- and radium-rays in air by a method depending on their diffusion. In the present paper accurate experiments are described using the same type of apparatus and Ra as source of ionisation. The ions are made to pass in a parallel stream through a slit into a steady longitudinal electric field. Owing to diffusion the stream spreads out, and the ratio of the amounts received by a central disc electrode and an outer ring is determined. From the various quantities involved—pressure, field, etc.—the value of N_e is determined [see Abstract No. 518 (1909)], where N is the number of molecules per c.cm. of gas at standard pressure and e is the elementary charge. The mean values obtained are 1.22×10^{10} for both positive and negative ions. The author has also made experiments with ultra-violet as source of ionisation, this being particularly advantageous for experiments at low pressures for which Townsend found an abnormal increase in the rate of diffusion for gases which had been thoroughly dried. The results are in general agreement with those of Townsend, and are discussed from the point of view of the tendency of the ions to assume the electronic state, the prevalence of this state depending on exactly the same conditions as those under which the abnormal increase in the rate of diffusion occurs. E. M.

218. *Lack of Symmetry of Positive and Negative Ions relative to the Condensation of Water Vapour in an Atmosphere of CO₂.* Besson. (Comptes Rendus, 155. pp. 711-718, Oct. 14, 1912.)—The apparatus used was described in a previous paper [see Abstract No. 1540 (1911)]. The CO₂ is submitted to the action of Röntgen-rays for 2 secs., and arrangements are made for establishing a field of 4 volts which can be reversed at will. The rain or fog which results from the condensation upon the negative ions when in excess, is much more intense than is the case with positive ions in excess. This phenomenon is much more apparent in CO₂ than in air. The fogs obtained have been photographed at 2 to 5 secs. after their production, and it is noted that in the absence of a field the condensation commences with an expansion of 1.88; the number of drops increases gradually until expansion 1.87 is reached, at which point the increase is clearly a maximum. The fog, however, increases still further in density up to an expansion of 1.476; above this value there is very little increase, and at 1.52 it apparently ceases. The lack of symmetry is visible for all expansions up to 1.476; for this value and for all higher degrees of expansion it can no longer be seen. It is very singular that the fog obtained without the field is practically identical with that seen when the negative ions are in excess, and this is so for all degrees of expansion, VOL. XVI.—A.—1918.

while with air the fog obtained without the field is much more intense than when the negative ions are in excess. When Ra is used as the ionising agent it is found that the inferior limit of the degree of expansion is the same as with Röntgen-rays; the want of symmetry is observed but is less marked; and the anomaly noticed with Röntgen-rays, does not occur. A. E. G.

219. Magnetic Rays. A. Righi. (Accad. Lincei, Atti, 21. pp. 811-815, Sept. 22, 1912.)—A reply to the criticism of More and Rieman based on their observation that magnetic rays are only formed in mixed gases containing nitrogen, and not in oxygen, hydrogen, CO₂, or illuminating gas [Abstract No. 1876 (1912)]. The author points out that magnetic rays are only formed within a narrow range of pressures, p.d.'s, and magnetic fields, and doubts that the experiments with other gases were sufficiently varied. The velocity of the electrons forming magnetic rays should not exceed 222 km./sec. It is natural to suppose that electrons emitted by different substances possess different velocities, and these may not be suitable for forming magnetic rays. E. E. F.

220. Secondary Rays Liberated by Canal Rays. H. Baerwald. (Deutsch. Phys. Gesell., Verh. 14. 19. pp. 867-874, Oct. 15, 1912.)—It has been shown [see Abstract No. 1564 (1912)] that the ability of canal rays, which have been analysed by an electric field, to produce the emission of light by phosphorescent substances differs according to their position. Through the comparison of the intensity of the phosphorescence with the energy of the exciting canal rays, it appears that not all the rays in the pencil are light-producers, but that this effect is in some way connected with the electric charge. The degree of action of charged is greater than that of uncharged particles. On the other hand, no difference was found between the action of positive and negative particles. The present experimental arrangements are the same as those previously described (*loc. cit.*). Quantitative results are shown in both tabular and graphical form. From these it is concluded that the excitation of secondary radiation by canal rays is dependent essentially only upon the number of the particles striking, and that a specifically greater efficiency (as in the case with the excitation of phosphorescence) of the charged over the uncharged particles does not exist. This result it appears can be explained by the fact that the phosphorescent substances are good insulators, and so the charged canal rays keep their charges, while when these rays strike against a metal they lose that charge and can now only act as uncharged particles so far as the generation of secondary rays is concerned. A. E. G.

221. Photoelectric Effect in Toluene. A. Naccari. (Accad. Sci. Torino, Atti, 47. p. 1076. N. Cimento, 4. Ser. 6. pp. 233-242, Sept., 1912.)—A plate of nickelled copper or other metallic plate is inserted upright in a trough filled with toluene. In front of the plate, and distant from it about 1 mm., is a piece of wire gauze. The plate and the gauze form electrodes for a current from about 100 cells. The current, which is of the order of 0.1 microamp., shows a gradual increase when the cell is exposed to daylight. This increase takes about a minute to start, and goes on for some 10 mins., amounting to some 20 per cent. After that the current spontaneously falls off, reaching its "dark" value after about another 10 mins. The effect is not due to heat. Infra-red rays produce about one-quarter of the effect. Blue light is more

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effective than red. The influence of the kind of metal is insignificant, though the effect is greater when the metal is illuminated as well as the liquid. The effect differs from the Becquerel photo-voltaic effect in that it only takes place when a current passes, and from the Hallwachs-effect in that it is independent of the direction of the current. E. E. F.

222. Photoelectric Fatigue. A. Becker. (Deutsch. Phys. Gesell., Verh. 14. 16. pp. 806-811, Aug. 80, 1912.)—In reply to criticisms by Hallwachs [Ibid. 14. 12. pp. 684-646, June 80, 1912] based upon Ullmann's investigations [Abstract No. 960 (1910)], the author publishes figures which show that, whether the mercury lamp is at a great or small distance, moist air in the neighbourhood of the photoelectric surface is capable of entirely abolishing fatigue for several hours' working. E. E. F.

223. Influence of the Nature of the Gas on Disintegration by Canal Rays. V. Kohlschütter. (Zeitschr. Elektrochem. 18. pp. 887-844, Oct. 1, 1912.)—The author alters his experimental arrangement. The bulb has two tubular diametrical attachments, from which the electrodes (Al cylinders joined to copper wires) project into the bulb; a third cylindrical attachment projects downward and can be lowered into an electric furnace; the cylinder contains a piece of cadmium whose vapours rise into the bulb. When the discharge is not turned on, the Cd-vapour deposited is evenly distributed over the glass walls and electrodes; but irregularities in the glass, so far unsuspected, are noticed. When the discharge current is passing, the distribution of the Cd is polarised, and the irregularities just mentioned become more prominent. At very low gas pressures the vapour is deposited chiefly on and near the kathode. With increasing gas pressure this preference for the kathode increases at first and then diminishes; the differential character of the condensation is more marked in an atmosphere of hydrogen than in nitrogen and in argon. From pressures of 0.8 mm. upwards the excess condensations take place on the anode; but the gas again plays a part, so that at 1.2 mm. pressure there is an excess deposit of 28 per cent. on the kathode in hydrogen, but no excess in argon. The author no longer suggests that the gas in the bulb enters into combination with the volatilised metal. But the nature of the gas enters in two ways: the atomic rays give off more energy when of greater mass (J. Stark); and the greater the mass, the less deeply the gas atom will be able to penetrate into the metal, so that more metallic atoms are secondarily emitted. H. B.

224. Electric Discharge in De La Rive's Tube. D. N. Mallik. (Phil. Mag. 24. pp. 500-507, Oct., 1912.)—When an electric discharge is passed through a De La Rive's tube at different pressures, it is found [see Abstract No. 2007 (1908)] that there are three stages of the discharge:—(1) At a high pressure the discharge is in the form of a shower, consisting of an infinite number of rays; (2) these, gradually, as the pressure is diminished, form into a single band or stream; (3) as the pressure is further reduced, the band broadens and ultimately fills the whole tube as a glow discharge. The electric discharge is next considered as a procession of corpuscles shot off from the negative electrode under the influence of the electric field and ions, positive and negative, produced by collision of these corpuscles with the molecules of the enclosed gas. The ions and the corpuscles exert electric force on one another, and as they are in motion they exert a magnetic force

as well. Also, since these masses are moving through the fluid medium, they must exert an additional apparent force on one another, besides experiencing a viscous retardation in the direction of motion. The above lines of thought are then mathematically worked out, and it is shown that the magnetic rotation corresponds to the second (or band) stage of the discharges. Other results in accord with experiment are obtained. E. H. B.

225. Emission of Charges in Vacuo. E. Henriot. (Le Radium, 9. pp. 224-227, June, 1912.)—Two elements, K and Rb, are clearly distinguishable by a radiation analogous to that from radio-active bodies, from ordinary substances, of which the activity is doubtful. Potassium emits β -rays approximately homogeneous and easily deviable, with a penetrating power about equal to that of the β -rays from uranium; this radiation is normal, atomic, and spontaneous. Rubidium emits slower β -rays, fairly homogeneous, with a penetrating power about equal to that of β -rays from radium; general characters, like those of the rays from potassium. Potassium, rubidium, and their salts emit, spontaneously *in vacuo*, electrical charges, of which at any rate a great part must be attributed to ionising β -rays. [See also Abstract No. 1416 (1912).] A. D.

226. Energy absorbed by Gas under Influence of Alternating Currents. A. Chassy. (Journ. d. Physique, 2. Ser. 5. pp. 826-831, Oct., 1912.)—An experimental investigation of the heat absorbed by a gas at atmospheric pressure and subject to alternating currents, and in continuation of previous work [see Abstract No. 1554 (1911)]. The author concludes that in this case the energy absorbed per sec. is proportional to the charge Q at each period, and not to the square of Q as would correspond to the case for metallic conductors. E. H. B.

227. Potential Measurements in the Neighbourhood of the Electrodes in Point-plane Discharge. [Miss] P. M. Borthwick. (Phil. Mag. 24. pp. 608-618, Oct., 1912.)—Chattock and Tyndall have shown that the value of a field at the surface of a discharging point, under various conditions, can be obtained by measuring the pull of the lines of force on its end, which they made hemispherical for the purpose [see Abstract No. 1482 (1910)]. The work described in the present paper was undertaken mainly with the view of obtaining support for their results, by measurement of the potential drop in the neighbourhood of a discharging point. It is found that the potential drop in the immediate vicinity of a point discharging on to a plate is independent of (a) the distance between the electrodes, (b) the current between the electrodes. The potential drop required to start the discharge is slightly greater at a negative than at a positive point. Experiments are described showing the effects on the potential drop, of supplying to the point ions from an external source. These results are discussed in the light of previous determinations of the field at a discharging point, obtained from measurements of the mechanical pull on its surface. The potential gradient in the vicinity of the plate is also measured over certain ranges of current and distance. A. E. G.

228. Discharge between Concentric Cylinders in Gases at Low Pressures. F. W. Aston. (Roy. Soc., Proc. Ser. A. 87. pp. 428-486, Oct. 81, 1912.)—The author has previously described investigations upon the length of the VOL. XVI.—A.—1918.

Crookes dark space and the relation between current and potential in the discharge between large plane Al electrodes in different gases at various pressures [see Abstract No. 915 (1912)]. For all the chemically active gases, and also for gases of the He group when these are not in a state of great purity, the two following equations were found to hold over a considerable range of the four variables:—

$$D = A/P + B/\sqrt{C}, \quad V = E + F\sqrt{C}/P,$$

where D is the length of the dark space, P the pressure, V the p.d. between the electrodes, and C the current density. In the present experiments parallel plane electrodes are replaced by two in the form of concentric cylinders, and the gases used are hydrogen and oxygen. A special form and arrangement of apparatus is described. Mean values of the constants A , B , E , and F for convex, plane, and concave Al cathodes are given in oxygen and hydrogen gases. The results described show that the relations between pressure, voltage, and length of the Crookes dark space in the discharge between concentric cylinders take much the same form as those in the discharge between parallel planes. Curvature of the surface of the kathode appears to have no influence upon the rate of alteration of the length of the dark space with change of current density, so long as the latter is measured at the surface of the kathode. *Ceteris paribus*, the length of the dark space is greater for a convex cylindrical surface than a plane, and for a plane than a concave one.

A. E. G.

229. *Conductivity of Gases in Ring Discharge without Electrodes.* R. Wachsmuth. (Ann. d. Physik, 89. 8. pp. 611–624, Oct. 15, 1912.)—An historical résumé. The conductivity curve begins at a small pressure ($p=0.08$ mm.), rapidly rises to a high maximum, then falls (as pressure increases) to a relatively high minimum at $p=0.18$ mm.; at $p=0.18$ mm. luminosity ceases; thereafter the conductivity first rises to another (lower) maximum and then steadily falls (the curve being somewhat concave upwards). Traces out the modifications in the form of the curve and the relations of the phenomena of luminosity to these. The latter maximum of the conductivity curve corresponds to the intersection of the curves for saturated and for unsaturated current. Throughout the region of luminosity (from $p=0.18$ mm. to $p=0.08$ mm.) the current is saturated, and as the pressure is reduced the number of ions produced increases.

A. D.

230. *Bunsen Flame as Wireless Detector.* G. Leithäuser. (Phys. Zeitschr. 18. pp. 892–894, Sept. 15, 1912.)—The flame of a Méker burner is used as a wireless telegraphy detector. The electrodes are a copper or Pt wire and a Pt plate covered with a potassium salt. The electrodes are from 5 to 10 mm. apart. No auxiliary e.m.f. is necessary, provided the electrodes are at different temperatures. The Pt plate must be glowing brightly. A potassium salt is found to give better results than those of Na, Li, Sr, Ba. The detector may be made nearly as sensitive as an electrolytic detector.

T. P. B.

231. *Electrical Vibrations on a Thin Anchor-ring.* Rayleigh. (Roy. Soc., Proc. Ser. A. 87. pp. 198–202, Aug. 21, 1912.)—Mathematical.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

232. Effect of Abrasion on the Conductivity of Selenium. F. C. Brown. (Phys. Zeitschr. 18. pp. 859-864, Sept. 15, 1912.)—The author describes an effect of abrasion discovered independently by himself and by Giltay, who made the selenium preparations experimented upon. Giltay produced the abrasions by a sand-blast, whereas the author produced them by filing. Both methods led to an increase in the conductivity, accompanied, however, by a diminution of the relative sensitiveness to light. It took about a month before the Se had recovered its initial electrical condition. When about one-third of the total Se present was filed off the conductivity fell to one-twentieth of its initial value, probably owing to the conversion of a large proportion of the conducting Se into the amorphous variety. The author points out that the conductivity is also increased by pressure and by radium rays. The latter may be due to the injury of the Se surface by the impact of the rays.

E. E. F.

233. Action of Selenium. A. Pochettino. (N. Cimento, 4. Ser. 6. pp. 189-208, Sept., 1912.)—Criticises the electronic theory of the light-action of selenium advocated by Ries and Pfund. A number of transformations of one allotropic form of Se into another are accelerated by light, so that the chemical theory of the light action has an experimental basis. Among these transformations are that of amorphous Se into the grey crystalline form, the solution of Se in CS₂ and its precipitation by evaporation or from colloidal suspension, and finally the transformation of amorphous into grey crystalline Se under the action of quinoline, aniline, pyridine, and piperidine. As regards the influence of temperature, it is doubtful whether all chemical action ceases at -185°, at which temperature Se is still light-sensitive. The author brings forward grounds for his belief that light-negative Se preparations can be obtained free from moisture, which would tell in favour of the chemical theory. He also points out that when the incident energy is great, the red rays have a greater effect for the same energy than the blue rays, which tells against the electronic theory. Finally, he maintains that the somewhat similar action of light on silver iodide, copper iodide, granular silver, antimonite, and sulphur, is best explained by a theory of chemical transformation.

E. E. F.

234. Effect of Vibration on the Electrical Resistance of Metals. H. L. Brakel. (Phys. Rev. 85. pp. 185-198, Sept., 1912.)—It has been shown that torsion and hydrostatic pressure both affect the resistance of metals [see Abstracts Nos. 491 (1909) and 441 (1911)] and the author has studied the effect of torsional vibration of various amplitudes on the resistance of a number of metals and alloys at various temperatures. Amplitudes up to 335° C. produce no measurable alteration at ordinary temperatures, but at higher amplitudes and temperatures the resistance is increased. Annealing at a bright red-heat completely removes the change brought about by vibration.

F. C. A. H. L.

235. Resistance of Powdered Conductors. A. A. Somerville. (Metalurgical and Chem. Engin. 10. p. 485, Aug., 1912.)—Powdered carbon and silicon placed in a porcelain tube into which metal rods were inserted, were successively examined as to change of electrical resistance when pressure was applied and when the temperature was changed from 20° to 1000° or 1100° C.

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It was found that there was practically no change in resistance after a pressure of about 850 lbs. per sq. in. was reached. Up to that pressure the resistance decreased rapidly. At room temperature the resistance of the powdered carbon was 2.2 ohms (50 times greater than solid carbon) and of the silicon 600,000 ohms (25,000 times that of a similar piece of solid Si). The carbon resistance decreased on heating to 0.6 ohm at 1000° C., the rate of change being twice as great as for solid carbon. The decrease in resistance of the silicon was much more rapid. The variation in resistance of solid silicon is first negative, then positive, and afterwards negative again.

J. J. S.

236. Electric Resistance of Mixtures of Copper and Mercury. A. P. Schleicher. (Zeitschr. Elektrochem. 18. pp. 998-1000, Nov. 15, 1912.)—On the instigation of Guertler [see Abstract No. 1901 (1912)] the author tried imitation alloys, prepared by drawing copper wires 0.5 mm. thick axially through a glass tube, 1.8 mm. in diam., placing the tube between two mercury troughs and filling it with mercury. There were eight wires. Taking one wire out after the other, he obtained conductivity measurements for different cross-section ratios Cu/Hg, and the conductivity of the mixture proved to be a linear function of the volume concentration, as expected. The wires were then broken up into pieces of 1 cm. length; the same law still held. The attempted experiments with smaller particles, to imitate mixtures with transverse arrangements or irregular mixtures, were unsuccessful.

H. B.

237. Influence of Pressure on the Electric Conductivity of Metallic Alloys. B. Beckman. (Ark. för Mat. Astron. och Fysik, Stockholm, 7. 42. pp. 1-18, 1912.)—Following the expression for the electric conductivity worked out by P. Drude in his electron theory the author has previously sought to express the conductivity (σ) of a metallic conductor as a function of the pressure (p) by means of the equation: $\sigma = \sigma_1 e^{ap} + bp^2$, where σ_1 is the conductivity at 1 atmo. pressure and a and b are constants. The term bp^2 in the index is a correction term: in the case of most of the substances examined by the author $b=0$. The constant a is the pressure coefficient of the specific electric conductivity. The investigation of gold-nickel alloys is described in the present paper. These two metals are in the solid condition only partially soluble in each other. Eight Au-Ni alloys have been examined. They were heated for some hours to 800° or 900° C. and drawn into wires of 0.8 mm. diam. The specific conductivity, pressure-coefficient, and temperature-coefficient were determined. The results of the observations are given in tables and curves, the percentage composition of each alloy being given. If two metals in the solid condition are only partially soluble in each other and, as in the case of the Au-Ni alloys, between two series of solid solutions a mixture interval with mean concentration exists, then the curve showing the electric conductivity as function of the volume concentration has the following appearance: Starting from the pure metal the curve quickly falls then bends a little towards the middle till it attains the concentration of the saturated solid solution. These two branches of the curve are connected by a straight-line middle portion that extends over the concentration of the mixture interval. According to Barus the following rule holds: If to a metal a small portion of another metal is added, there exists between the resistance and the temperature-coefficient α of the alloy so formed the following relation: $W = n/(a + m)$; where n and m are two constants which depend

only on the peculiarities of the metal which predominates in the mass. The relation may be expressed : $\alpha = n\sigma - m$. According to W. Guertler this linear relation between α and σ is only maintained so long as the added mass of metal remains under the saturation concentration of the solid solution. The linear relation between the conductivity and pressure coefficient in the case of the Au-Ni alloys appears from one of the author's curves to hold with alloys which contain up to 11.2 volumes per cent. (16.7 atomic per cent.) of Ni. With Au-Ag alloys the pressure coefficient is a linear function of the temperature coefficient. In the case of the Au-Ag alloys the pressure coefficient can be expressed as a function of the conductivity by the relation $\alpha = \eta\sigma + \delta$, where $[\eta]_{\text{Ag}} = 4.00 \times 10^{-12}$. For the Au-Ni alloys which contain up to 11.2 volumes per cent. the same relations hold, when $[\eta]_{\text{Ni}} = 2.15 \times 10^{-1}$. The ratio between these two constants is : $[\eta]_{\text{Ag}}/[\eta]_{\text{Ni}} = (\text{atomic weight of Ag})/(\text{atomic weight of Ni}) = 1.84$. The investigations show that nickel in small amount in the solid state is soluble in gold. J. J. S.

238. Electric Attraction between two Conducting Spheres. A. Guillet and M. Aubert. (Comptes Rendus, 155, pp. 708-711, Oct. 14, 1912.)—The mutual action F between two spheres whose radii are a and b respectively and the distance between the centres of which is x is given by—

$$F = -(V_1^2/2) \sum_1^{\infty} a^{n+1} b^n \frac{\partial}{\partial x} \cdot \frac{1}{P_n} \\ + V_1 V_2 \sum a^{n+1} b^{n+1} \frac{\partial}{\partial x} \cdot \frac{1}{P_{2n+1}} \\ - (V_2^2/2) \sum a^n b^{n+1} \frac{\partial}{\partial x} \cdot \frac{1}{Q_{2n}},$$

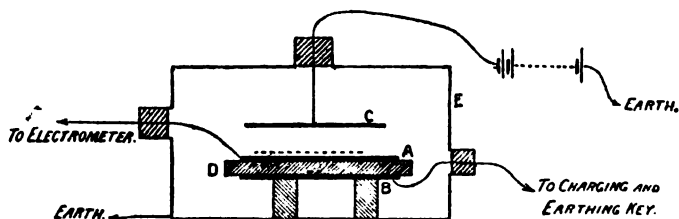
where V_1 and V_2 are the potentials of the two spheres and P and Q are polynomial expressions in x of the degree marked by the subscript and the coefficient of the first term of which is unity. The polynomials P_{2n+1} and Q_{2n+1} are identical and

$$P_{2n} = xP_{2n-1} - b^2 P_{2n-2}, \quad Q_{2n} = (1/x)(P_{2n+1} + b^2 P_{2n-1}).$$

The properties of these polynomials are investigated, and their connections with Heine's spherical functions are found. A. R.

239. Electric Spark-gap formed by two Conducting Spheres. A. Guillet and M. Aubert. (Comptes Rendus, 155, pp. 820-828, Oct. 28, 1912.)—One of the spheres is fixed to an insulated plate which can be moved in three directions mutually at right angles, through distances which can be accurately measured by micrometer gauges. The moving sphere is either made of aluminium and hollow or consists of a celluloid balloon, the surface of which is silvered. It is suspended by a fine thread, the other end of which is connected with the indicator. Various types are made. When the spheres are electrified certain forces are called into play. Methods of computing the charges, the potentials, and the mutual action leading to disruption are given. The computations are made by the help of the polynomials found in the previous paper. [See preceding Abstract.] A. R.

240. Theory and Measurement of Residual Charges. A. Anderson and T. Keane. (Phil. Mag. 24. pp. 487-445, Sept., 1912.)—The authors consider the case of a single dielectric between parallel plate electrodes in which the specific inductive capacity and specific resistance are finite and continuous functions of the distances from one of the plates. Let v be the potential of the first plate and that of the other zero. Then if τ is the specific resistance and K the specific inductive capacity at a point whose distance from the first plate is x , we have $d/dx \cdot (1/\tau \cdot dv/dx) = 0$ and $d/dx \cdot (K \cdot dv/dx) = -4\pi\rho$, where ρ is the volume density of electricity. Hence $-1/\tau \cdot dv/dx$, which is the current c per unit area, is constant and the whole quantity of electricity stored in the dielectric is $(Ac/4\pi) (K_0\tau_0 - K_1\tau_1)$, where A is the area of the plates and K_1 and K_0 are the specific inductive capacities and τ_1 and τ_0 the resistances at the surfaces of the dielectric. Thus the amount of the residual charge, or the residual discharge depends only on the surface values of K and τ (except in so far as these affect the current c). The charge Q_1 on the first plate is $Ac/4\pi \cdot K_1\tau_1$. If q is the charge in the dielectric we have, for a homogeneous medium $q/Q_1 + (\tau_0 - \tau_1)/\tau_1$. If this be so we must explain the existence of q by a difference between τ_0 and τ_1 , τ_0 being greater than τ_1 , i.e. the resistance of the dielectric at the cathode must be greater than at the anode. In order to show how this can be brought about by the field of force, the electron theory is made use of, the residual charge being due to changes



of the surface resistances owing to a displacement of the free electrons under the action of the field of force, and it is shown that $q/Q_1 = (n_1 - n_0)/n_0$, where n_1 , n_0 are the numbers of the free electrons per unit volume at the anode and cathode respectively. Hence it is not necessary for a residual charge for the dielectric to be heterogeneous. To measure the residual discharge a plate of sulphur was put between two zinc plates A, B (see Fig.), the upper one, A, being connected to an electrometer. On A was placed a little uranium oxide and some distance above it was hung a third plate which could be connected to one terminal of a battery. A was first earthed and B charged to a definite voltage V for a definite time. B was then earthed and A insulated immediately afterwards by means of a special key. The electrometer will now charge up, but will be continuously discharged by the ionised air between C and A. The time required for the needle to return to resting point will measure, with a slight correction, the residual charge. The curve showing the relation between q/Q and the applied voltage approximates closely to an equilateral hyperbola. In all cases the time of charging was always greater than that required to make the residual charge closely approach its asymptotic value. It was found that no difference was produced by having plates of different metals; also the smallest electric force, if applied long enough to the dielectric, will produce some displacement of the free electrons. In the case of the particular experiment carried out it was found that at high voltages the value of n_0/n_1 becomes 19/20. The rest of the paper consists of a mathematical discussion of the problem which arises out of the experiment.

241. The Law of Superposition. New Experiments on Ionised Dielectrics. A. Zaroubine. (*Le Radium*, 9. pp. 885-895, Nov., 1912.)—The author describes experiments on dielectrics ionised by Becquerel-rays. From the results obtained by passing a current through a layer of ozokerite, 2 mm. thick, ionised by rays from radium, he concludes as follows:—The ionisation current follows Ohm's law, although the e.m.f. was varied from 0 to 2000 volts. The ionisation current diminishes gradually and finally becomes zero. The shape of the current curve is hyperbolic. When a direct current traverses an ionised dielectric the law of superposition ceases to be applicable. In proportion, as the duration of the direct current increases the relative quantity of electricity transported, the inverse current of polarisation diminishes. Under the action of radium rays an e.m.f. develops in the dielectric, which produces a current analogous to that of polarisation. These results were also obtained with diphenyl. A. R.

242. The Mutual Inductance of Coaxial Solenoids. G. R. Olshausen. (*Phys. Rev.* 85. pp. 148-152, Aug., 1912.)—The author gives improved formulæ for calculating the mutual inductance of coaxial current sheets. He uses β -function formulæ and shows by actual computation that the labour necessary is very considerably lightened. In the example considered, the current sheets are concentric as well as coaxial, and the results are given to eight-significant figures. A. R.

243. The Mutual Induction between two Parallel Coaxial Circular Currents. E. Mathy. (*Journ. de Physique*, 2. Ser. 5. pp. 987-990, Dec., 1912.)—The author corrects the formula which he had given twelve years ago in Weierstrass' notation. Grover has recently pointed out that one of the series originally given was erroneous. He now gives the formula in terms of Gauss's hyper-geometric series. A. R.

244. The Motion of the Needle of a Quadrant Electrometer. W. F. G. Swann. (*Phil. Mag.* 24. pp. 445-451, Sept., 1912.)—In the measurement of small currents by observation of the rate of movement of the needle as the electricity enters one of the quadrants it is found that, owing to the inertia of the needle, the latter does not move with uniform velocity, even though the electricity passes in at a uniform rate. As considerable errors may result unless suitable precautions are taken, the author discusses the theory of the method and gives a method of avoiding the error. The equation of motion of the needle being $k \cdot d^2\theta/dt^2 + b \cdot d\theta/dt + a\theta = F(t)$, two cases are considered, viz. (1) when the p.d. driving the electricity into the quadrant is large compared with the rise of the potential of the quadrant during the observations; (2) when the alteration in current due to the rise in potential of the quadrant is of importance. For full particulars the original should be consulted.

W. C. S. P.

245. Photographic Recording of Ballistic and other Rapid Phenomena with the Aid of the Quenched Spark. C. Cranz and B. Glatzel. (*Deutsch. Phys. Gesell., Verh.* 14. 10. pp. 525-535, May 30, 1912. *Electrician*, 70. pp. 958-959, Feb. 28, 1913.)—After briefly reviewing earlier methods used for the photographic recording of rapidly occurring processes, such as ballistic phenomena, the authors describe the method employed by them, which enables a regular succession of pictures to be taken of a single bullet fired from a pistol, on a falling photographic plate. A

direct-current quenched gap (of the Scheller type using alcohol) is used, connected to 700-volt mains. The capacity in the gap circuit is made up of mica condensers variable from 25,000 to 600,000 cm.; the inductance is kept very small. This inductance and that of the secondary (= 1800 cm.) are in the form of flat spirals so as to secure very close coupling. In the secondary is a small spark-gap (used to illuminate the object to be photographed) shunted by a condenser. The exposures are made on a film which runs over two drums of 89 cm. circumference, capable of making a maximum of 9000 revs. per sec. It is found that the number of sparks passing can be adjusted accurately to any number between 200 and 100,000 per sec. by (1) altering the capacity in the primary circuit; (2) regulating the intensity of the current in the primary. Reproduced photographs show the capabilities of the method. With 6400 sparks per sec. the firing of a shot at a piece of wood is seen in all its phases. With 10,000 sparks per sec. the movements of the cartridge in the operation of an automatic pistol can be followed. Other records show the issuing of a bullet from the muzzle, and the accompanying phenomena, taken with spark frequencies of 56,600, 72,000, and 92,200 per sec. The possible application of the method to the investigation of electric double refraction is referred to.

L. H. W.

246. *Photographic Registration of α -Particles.* H. Geiger and E. Rutherford. (Phil. Mag. 24. pp. 618-623, Oct., 1912.)—In a previous paper [Abstract No. 1627 (1908)] the authors have described an electrical method of counting the α -particles from radio-active substances, an electrometer being used to detect the entrance of an α -particle into the testing vessel. With this arrangement it was not possible to count with accuracy more than about 10 α -particles per min. Since then a string electrometer has been used, and with this apparatus 1000 α -particles per min. may be counted. It is necessary, for accurate work, that the electrometer fibre after displacement should return rapidly to its equilibrium position. This was effected by connecting the fibre through a comparatively low resistance to earth. Suitable resistances were made from capillary tubing filled with a mixture of xylol and alcohol. The large back leak thus obtained has the advantage of cutting out the great majority of slow electrical disturbances, for only rapid changes of potential make their effect visible. The detecting vessel consisted of a metallic hemisphere, near the centre of which was a spherical electrode supported by a metal rod. The α -particles entered the vessel through a small opening in the middle of the curved side covered with a thin sheet of mica. Helium at suitable pressure was introduced into the apparatus, and with this arrangement the throws were remarkably uniform, so that it was easy to recognise by the length of the throw when two or even three α -particles entered the vessel in rapid succession. The photographic registration apparatus constructed by Edelmann was found to answer very well. The speed of the film could be adjusted over a wide range according to the number of α -particles to be registered per min. Experiments are in progress to test whether an electric method can be employed to count *recoil* atoms with certainty.

A. W.

247. *A Magnetic Shunt Vibration Galvanometer.* H. Tinsley. (Electrician, 69. pp. 939-941, Sept. 13, 1912.)—The majority of vibration galvanometers on the market suffer from lack of stability of the coil at low frequencies. The author has evolved an instrument of the Kelvin type in which tuning is brought about by means of a magnetic shunt. He defines the ratio of the increased

sensibility of such an instrument when used with alternating current of the same periodicity as the natural frequency of the instrument, to its sensibility to direct current, as the "resonance multiple." In order to make this ratio as high as possible the molecular friction of the suspension was made as small as possible by using a fine silk fibre, and the mirror was made of an elongated shape so as to reduce the air friction. The silk fibre is kept taut by a light spring at the top, and so prevents the suspended magnet *M* being drawn sideways on to the poles of the controlling magnet. By means of a turning screw a magnetic shunt is made to traverse the two limbs of the permanent magnet and so vary the controlling force of the needle. The instrument gives a narrow range of resonance, a variation in frequency of 2 per cent. above or below the critical tuning at $50\sim$ reducing the deflection by 80%. The advantages of this instrument are : (1) interchangeable suspensions ; (2) interchangeable coils of different resistances ; (3) great stability of zero ; (4) ease of tuning without disturbing the zero. The suspension is of a shape which permits of its enclosure in glass so that at high frequencies it is possible to reduce air damping by working *in vacuo*. The disadvantages of this type of instrument are its rather long time in coming to rest (about 10 secs.), and its liability to get into resonance with stray magnetic fields of the same frequency.

W. C. S. P.

248. Electrocapillary Pulsation of a Mercury Meniscus. **A. P. Roshdestvensky** and **W. C. McC. Lewis.** (Faraday Soc., Trans. 8. pp. 220-280 ; Discussion, pp. 280-281, Oct., 1912.)—Lippmann's electrocapillary measurements with sulphuric acid solution have been repeated and confirmed, using a somewhat modified form of his apparatus. No abnormal results were obtained. With other solutions—mercuric cyanide solutions—it was accidentally observed, however, that the meniscus under given conditions is not at rest, but oscillates regularly round a mean position. The occurrence of this pulsation is confined within fairly narrow limits, the determining factors being : (1) size of capillary ; (2) magnitude of e.m.f. ; (3) concentration of mercury ions.

L. H. W.

249. Hydroelectric Machines. **A. Bernini.** (N. Cimento, 4. Ser. 6. pp. 204-206, Sept., 1912.)—A further quantitative study of hydroelectric machines and influence machines based on similar principles [see Abstract No. 1594 (1911)]. It is found that in many cases the energy of charge exceeds the energy of fall which produces the charge. This peculiarity is investigated by substituting millet seeds for drops of water. It is found that there is a certain amount of frictional electrification which accounts for the excess.

E. E. F.

250. New Absolute Electrometer. **A. Guillet** and **M. Aubert.** (Journ. de Physique, 2. Ser. 5. pp. 990-1006, Dec., 1912. Paper read before the Soc. franç. de Physique, Nov. 14, 1912.)—A more complete account of the arrangement described in Abstract No. 1556 (1912).

251. New Type of Compass Declinometer. **R. L. Faris.** (Terrestrial Magnetism, 17. pp. 109-114, Sept., 1912.)—Illustrated.

ALTERNATING CURRENTS AND MAGNETISM.

252. Internal Force in Ferromagnetic Bodies placed in a Magnetic Field. **F. Piola** and **L. Tieri.** (Accad. Lincei, Atti, 21. pp. 885-848, Sept. 22, and VOL. XVI.—A.—1918.

pp. 481-488, Oct. 18, 1912.)—The author proposes to measure the internal force in a ferromagnetic body placed in a magnetic field by observing the change in shape which the body undergoes when subjected to an external force. For this purpose the field must vary in such a cycle that for each of its values the previous history of the body, and hence the induction, is known. The external force applied must also be cyclic, each value corresponding to a definite deformation, and the field and external force must act simultaneously. These conditions are attained by using an alternating current of constant frequency and amplitude for the production of the field, and a second alternating current for applying the external force, the two currents acting simultaneously, and the variation of the second being adjustable so as to compensate the effects of the first. A preliminary experiment has been made on the longitudinal tension produced in a nickel wire, 0.7 mm. in diam., and 81 cm. long, placed vertically along the axis of a copper wire helix of diam. 1.4 cm., through which passed an alternating current. The upper end of the nickel wire was fixed, and the other, connected to one arm of a brass lever with a mirror attached, was prolonged in a piece of aluminium, to which was attached a large copper coil with vertical axis. The reciprocal action between this and a second copper coil, both traversed by an electric current, produced the external force, and as a result of the experiments, it is concluded that the longitudinal tension in the nickel is proportional to the square of the magnetic field in which the body is placed, which does not agree with Maxwell's theory, but is in accord with that of Kirchhoff.

W. H. St.

253. Magnetic Studies. S. R. Williams. (Phys. Rev. 35. pp. 282-287, Oct., 1912.)—In the relation between the Joule magnetostrictive effect and the magnetic induction in the same specimen of steel, the author had previously pointed out that the max. elongation of the steel rod in the Joule-effect, and the knee of the induction curve occur at the same magnetic field strengths. It is suggested that both were due to one cause, which might be the behaviour of the elementary molecular magnet. A model consisting of 27 ellipsoidal elements was then built up in cubical form which showed that both the orientation and the distance apart of the elements affected the magnetic properties. [See Abstracts Nos. 790 (1911), 589 and 1110 (1912).]

E. H. B.

254. Magnetic Reaction of a Copper Disc rotating between the Poles of a Magnet. W. G. Cady and F. G. Benedict. (Phys. Zeitschr. 13. pp. 920-980, Oct. 1, 1912. From the English.)—In measurements of the activity of a man it is customary to employ the bicycle-ergometer in which a copper disc is made to spin in a magnetic field, and the heat evolved is measured calorimetrically. The heat given out through the rotation of the pedals does not increase proportionately to the speed, but reaches a max. value and then diminishes. For the speeds generally employed in practice the heat evolved per turn can be taken as practically constant. The paper gives theoretical considerations and experimental tests in support of this statement.

A. D. R.

255. Heusler Alloys. F. Heusler and E. Take. (Faraday Soc., Trans. 8. pp. 169-184, Oct., 1912. Phys. Zeitschr. 13. pp. 897-908, Sept. 15, 1912.)—The authors discuss in detail their hypothesis advanced in 1909 that the magnetism of the Heusler alloys is due to the occurrence of ternary chemical

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compounds of Cu, Mn, and Al. These molecules, which are all supposed to be magnetic, have the general formula $Al_x (Mn, Cu)_{3-x}$, where x has any of the values 1, 2, ... Granting this hypothesis they attempt to explain some of the effects observed on subjecting the bronzes to annealing and ageing processes.

A. D. R.

256. Heusler Alloys. A. D. Ross. (Faraday Soc., Trans. 8. pp. 185-194, Oct., 1912.)—The author adduces magnetometric, thermometric, and metallographic evidence in support of his view that the Heusler alloys which are magnetic consist of solid solutions of varying concentration of the binary compounds Cu_3Al and Mn_3Al , and that the magnetic properties are dependent on the occurrence of such solid solutions. Details are given of the variation of magnetic properties of the alloys with the constitution and with thermal treatment, and notes are also given on the general magnetic properties of alloys of $Cu + Mn + Sn$, $Cu + Mn + Sb$, $Cu + Mn + Bi$, $Cu + Mn$, $Cu + Al$, $Mn + Sb$, $Mn + B$.

A. D. R.

257. Heusler Alloys. A. A. Knowlton and O. C. Clifford. (Faraday Soc., Trans. 8. pp. 195-206, Oct., 1912.)—The authors discuss the best methods of preparing and treating the Heusler alloys so as to secure high magnetic permeability. They state that, while the hypothesis of a chemical compound [see Abstract No. 255 (1918)] is perhaps the simplest hypothesis as to the nature of these ternary alloys, their tests and the extreme variability of the alloys point to the metal being of the nature of a solid solution.

A. D. R.

258. Magnetic Properties of Nickel and Manganese Steels. E. Colver-Glauert and S. Hilpert. (Faraday Soc., Trans. 8. pp. 184-148, Oct., 1912. Iron and Steel Inst., Journ. 86. pp. 295-301, 1912. Abstract in Electrician, 71. pp. 102-108, Oct. 25, 1912.)—A series of nickel and manganese steels was investigated with reference to the influence of thermal treatment on their magnetic and metallographic properties, and the following are among the conclusions arrived at. There is a distinct connection between thermal treatment and magnetic properties, but no definite one between metallographic structure and magnetic properties. Any modification which is produced by quenching these alloys from $1200^\circ C$. is in all cases strongly magnetic at room temperature; in the case of the 25 per cent. nickel steel, two superimposed temperature-hysteresis loops exist. Further, it is possible to define various constituents by their magnetic properties, and the metallographic structure of artificial nickel-iron alloys closely approximates that of meteoric iron. The allotropic theory of the magnetic properties of iron alloys is not upheld by the facts.

G. E. A.

259. Magnetic Properties of a Variety of Special Steels at Low Temperatures. J. G. Gray and A. D. Ross. (Faraday Soc., Trans. 8. pp. 115-138, Oct., 1912.)—Specimens of iron, carbon steels, chrome, silicon, phosphorus and tungsten steels of given composition were tested at room temperature and at $-190^\circ C$. after normalising, annealing at $900^\circ C$., quenching at $450^\circ C$., and quenching at $900^\circ C$. respectively. The effect of cooling to the temperature of liquid air is in general to diminish the permeability for low values of the magnetising force, and to augment it for high values. A magnetisation curve for $-190^\circ C$. lies initially below and finally above the curve corresponding to room temperature. The results are given in tabular form, and, in summarising, the crossing point of the I-H curves for 15° and 190° is stated for VOL. XVI.—A.—1918.

each variety of steel. In all cases the crossing point is higher, the greater the amount of the added element. This holds for the steels in any of the above-mentioned conditions.

G. E. A.

280. Kerr Magneto-Optic Effect in Ferromagnetic Compounds. P. Martin. (Ann. d. Physik, 89. 8. pp. 625-686, Oct. 15, 1912. From the Bosscha Laborat. Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 188-147, Sept. 8, 1912.)—Tests on certain manganese and iron compounds yielded the following results: (1) In MnB any rotation is less than $0.8'$. (2) In Mn₂Sn the effect is small, as is to be expected from the small susceptibility. The rotation is negative and gives a decided numerical minimum in the blue part of the spectrum. (3) MnSb gives much larger negative rotations, the largest rotation in the visible spectrum being at $500\ \mu\mu$, and the minimum at about $580\ \mu\mu$. (4) MnBi gives no rotation at 468 and $617\ \mu\mu$. There is a small positive rotation in the green, and negative rotations in the blue-violet and red. (5) The curve for Fe₃C. resembles that for MnSb, the max. negative rotation being at about 450 and the minimum negative rotation at $560\ \mu\mu$. (6) The rotations for pyrrhotin were positive and showed the expected variation according to the orientation of the reflecting surface with respect to the axis.

A. D. R.

261. Kerr-Rotation for Transverse Magnetic Fields. L. R. Ingersoll. (Phys. Rev. 85. pp. 812-821, Oct., 1912.)—Three types of Kerr-effect exist, corresponding to the three possible cases of magnetisation: with the lines of force normal to the reflecting surface, or lying in the surface and respectively parallel or perpendicular to the plane of incidence of the light. Only a single determination for the last case has previously been made (by Zeeman) for iron. The method used for the determination of optical constants [see Abstract No. 829 (1911)] was found to be capable of such accuracy that it seemed desirable to study the effect of various directions of magnetisation on the azimuth of the reflected light. The results for transverse or "equatorial" magnetisation were found to follow closely the predictions made by C. H. Wind in his magneto-optic theory. Light from a Nernst glower is plane-polarised and reflected from the surface under trial. It will then in general be reduced to an elliptically polarised vibration, of which the two components are taken by passage through a large double-image prism analyser. The intensity of these two components can be compared for any wave-length by a special spectrophotometric apparatus. The ratio of these two components would enable us to find at once the "azimuth of restored plane polarisation," if this state of polarisation is imagined restored by a suitable phase-change, but it is found more convenient to keep the two components of the same intensity by changing the azimuth of the incident polarised light. This azimuth of restored polarisation—the principal azimuth if the corresponding angle of incidence is the principal incidence—is then read off as the complement of the azimuth of the polarising agent. Two distinct series of observations were made. In the first case parallel light was incident on the test surface, while in the second the light converged to an image of the Nernst glower at this surface. The results were in substantial agreement. For steel and cobalt the agreement between the experimental results and those calculated from Wind's theory is very good. In the case of Ni the agreement is only qualitative. Experiments with Heusler's alloy show that magneto-optic effects, if they exist at all in this metal, are less than $\frac{1}{100}$ as large as the corresponding effects in steel.

A. W.

262. *Magnetic Disturbances, Sun-spots, and Solar Corona.* A. L. Cortie. (Observatory, No. 458. pp. 856-857, Oct., 1912. Summary of paper read before the British Association.)—Curves for the period 1898-1911 are compared of mean daily dial-area of sun-spots, mean daily range of declination and horizontal force, and yearly numbers of great and moderate magnetic disturbances. There is general accord in the curves, but noticeable discrepancies are shown.

The monthly numbers of great and very great magnetic storms for 28 years, 1889-1911, exhibit decided maxima near the equinoxes, and at such times the direction of the sun's rotation is least inclined to the ecliptic. When the earth moves into the planes of the spot zones in mid-latitudes, great magnetic storms are more frequent. The coronal streamers are long, and are mainly confined to regions adjoining the solar equator at periods near sun-spot minima. At such periods the prominences are also fewer, and their regions fall towards the equator. The long streamers of the corona appear to be "associated with the regions of prominence activity," while the shorter plumed streamers radiate from sun-spot centres. The occurrence of magnetic storms appears to be due to the earth passing through streams of electrified particles emitted from the sun.

C. P. B.

263. *Initial Susceptibilities of Nickel at Low Temperatures.* A. Perrier and H. Kamerlingh Onnes. (Archives des Sciences, 84. pp. 522-584, Dec., 1912.)—The full paper corresponding to Abstract No. 750 (1912).

264. *Magnetic Determinations and Chart Corrections obtained by the "Carnegie" from Balavia to Manila and thence to Suva, Fiji, 1911-1912.* L. A. Bauer and W. J. Peters. (Terrestrial Magnetism, 17. pp. 141-144, Sept., 1912.)

RADIOLOGY AND ELECTROPHYSIOLOGY.

265. *Opacity to X-Rays of Fabrics suitably Impregnated with Lead Salts.* L. G. Droit. (Comptes Rendus, 155. pp. 706-708, Oct. 14, 1912.)—In order to improve the means of protecting operators habitually working with X-rays, the author makes use of the property exhibited by silk of absorbing considerable proportions of metallic salts. He has obtained a silk-waste fabric containing 68 per cent. of mineral matter consisting of lead phosphostannate : phosphoric acid, 8 ; tin oxide, 24 ; lead oxide, 84 ; lime, soda, etc., 2 per cent. on the weight of the fabric. Six thicknesses of this fabric form a very effective protection and are at the same time extremely supple.

T. H. P.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

266. *Crystal Space Lattices*. A. E. H. Tutton. (Nature, 90. pp. 806-809, Nov. 14, 1912.)—Describes diffraction patterns produced by Röntgen-rays passing through zinc-blende, obtained by M. Lüne at Munich, and fully published in July, 1912 (K. Bayer. Akad. München, Ber. p. 808, June 8, and p. 868, July 6, 1912). Out of an excellent crystal of zinc-blende a plate was cut 1 cm. square and $\frac{1}{4}$ mm. thick, parallel to a cube face, and perpendicular to a tetragonal axis of symmetry. A beam of X-rays 1 mm. in diam. impinged normally upon it, after passing through screens to eliminate secondary radiations, the last screen being a plate of lead 1 cm. thick pierced with a hole 0.75 mm. in diam. After traversing the zinc-blende plate, the beam was received on a photographic plate. The exposure varied from 1 to 20 hours. The result shows a central dark circle surrounded symmetrically by 16 smaller black spots of elliptical shape, about 2 mm. long, arranged in a square. A fainter square appears within the intense square, and others outside. These patterns correspond to the holohedral or full symmetry of the cubic system, and show that it is the space lattice (Raumgitter) of the crystal itself which produces the pattern. W. H. Bragg. (Ibid. pp. 860-861, Nov. 28, 1912.)—Bragg replies to the above. Any plane within a crystal which is "rich" in atoms may be regarded as a reflecting plane, and the position of the spots can be calculated from the laws of reflection. E. E. F.

267. *Absorption of Helium and other Gases under Electric Discharge*. R. J. Strutt. (Roy. Soc., Proc. Ser. A. 87. pp. 881-884, Oct. 2, 1912.)—Berthelot announced in 1896 that argon and helium, when submitted to the silent discharge in the presence of benzene or carbon disulphide, were absorbed by these substances and could afterwards be extracted from the solid substances deposited on the walls of the vessel. The author repeated the experiment with helium in a Siemens tube containing mercury, a layer of CS_2 floating on it, and helium. The silent discharge continued for 120 hours produced no contraction of volume; a solid deposit was formed, but it yielded no He when heated. In a test experiment nitrogen was absorbed under similar conditions. In other experiments (bulbs with Al-wire electrodes) nitrogen was absorbed by phosphorus (which is converted into red phosphorus by the silent discharge) and not liberated again when the red phosphorus deposited on the walls was afterwards heated. Hydrogen was also absorbed and not re-liberated by heating. In the case of helium a slight absorption was observed and the gas liberated again by heating, so that the absorption by phosphorus appeared to be mechanical in the case of He, but chemical in the case of H and N. H. B.

268. *Theory of the Solid State*. E. Grüneisen. (Ann. d. Physik, 89. 2. pp. 257-306, Sept. 24, 1912.)—Bases a fuller theory of the solid state of monatomic elements upon the data accumulated by the Reichsanstalt. The method adopted is based upon that of Mie [Abstract No. 1450 (1904)], who assumes both attractive and repulsive forces between the atoms, the latter diminishing more rapidly than the former as the distance increases. Among the matters dealt with are the change of atomic frequency with temperature

and pressure; heat of sublimation at the absolute zero; expansion and amplitude of oscillation; frequency, melting-point, and compressibility; and latent heat of fusion. Some of the results arrived at are the following:—The relative expansion between absolute zero and melting-point is approximately the same for all monatomic elements. The ratio of the mean amplitude to the mean distance of adjacent atoms increases with the temperature in nearly the same manner as the square root of the volume expansion. With the same expansion, the amplitude is nearly the same fraction of the atomic distance. Hence, at their fusing-points, the ratio of the mean amplitude to the mean atomic distance is nearly the same for all monatomic solids. E. E. F.

269. Unusual Case of Specific Gravity. A. L. Hyde. (Amer. Chem. Soc., Journ. 84. pp. 1507–1509, Nov., 1912.)—When *p*-nitrotoluene is dissolved in carbon disulphide, the specific gravity of the solution is less than that of either the solvent or solute. The decrease in the sp. gr. is nearly proportional to the percentage of *p*-nitrotoluene in the solution, the relation being expressed by the formula $D = 1.2660 - 0.0018a$, where a is the percentage of *p*-nitrotoluene present. Further experiments showed that both carbon disulphide and *p*-nitrotoluene always tend to increase the volume of solutions into which they enter, although the specific gravity of the solution is not in all cases less than that of the pure solvent. *o*-Nitrotoluene seems to have a similar effect. T. S. P.

270. Molecular Statistics of some Chemical Actions. R. J. Strutt. (Roy. Soc., Proc. Ser. A. 87. pp. 802–809, Oct. 2, 1912.)—When a gas is absorbed or chemically acted on by a solid surface, the rate at which the change proceeds must depend on the number of collisions made by the gas molecules with the surface, and the question as to the number of such collisions which are required for the achievement of a successful result has been examined in the case of the action of ozone on silver and of active nitrogen on copper oxide. In the ozone experiments a stream of air was made to pass through a discharge tube, in which the air becomes charged with ozone and nitric oxide. By causing the gases to pass through a silver gauze partition, the ozone is destroyed and the glow ceases. The minimum area of silver surface which suffices to produce this result has been determined, and the data show that less than 1.6 collisions with the silver surface suffice to destroy a molecule of ozone. This result points to the conclusion that one collision with a silver surface is sufficient to destroy an ozone molecule. Similar experiments with active nitrogen and copper oxide gave 780 as an upper limiting value for the number of collisions which occur before a molecule of active nitrogen is destroyed by a surface of oxidised copper. The data obtained by Jones and Chapman for the rate of decomposition of ozone in the absence of surface effects have also been examined statistically, and the author calculates that at 100° C. two molecules of ozone must, on the average, collide 6×10^{11} times before the favourable type of collision occurs which results in chemical decomposition. T. S. P.

271. Nature of Chemical Action produced by α -Particles. S. C. Lind. (Journ. Phys. Chem. 16. pp. 564–618, Oct., 1912. Le Radium, 9. pp. 426–481, Dec., 1912.)—Previous experiments by the author have shown that when α -particles pass through oxygen the number of molecules of ozone formed is equal to the number of ions produced by the α -particles [Abstract No. 1288 (1912)]. The various available data on chemical effects under radio-active influences including experiments of Cameron

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and Ramsay, Debierne, Usher, and of the author have now been examined, and in all cases the number of molecules undergoing reaction is found to be little different from the number of ions produced. The list of reactions that have been studied include reactions of combination and of decomposition; reactions proceeding with, as well as opposed to, the chemical free energy; even reactions in liquid systems and solutions obey the same principle. In the various experiments it is necessary to take into account all the conditions regarding pressure, length of path of the α -particles, etc., and formulæ are deduced for the calculations with different-sized vessels, etc. The results show that there is no experimental evidence that the action of the β -rays ever exceeds the subordinate proportion that corresponds to the relative amount of ionisation produced by them as compared with that by α -particles.

E. M.

272. *New Modification of Sulphur.* A. H. W. Aten. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 572-583, Nov. 28, 1912.)—If a solution of rhombic sulphur in sulphur chloride, saturated at the ordinary temperature, is heated at about 170° and then cooled, it is found that a further and considerable quantity of sulphur may be dissolved in the liquid. It is shown that this cannot be due to the formation of S_{μ} from S_{λ} , for the solubility of S_{μ} in sulphur chloride is very small at the ordinary temperature, and if solutions saturated with S_{μ} at a higher temperature are cooled down, this separates out quite readily. Systematic determinations of the solubility of rhombic sulphur in sulphur chloride which has been heated with varying proportions of sulphur at a definite temperature and then cooled to either 25° , 0° , or -60° , give data which point to the formation of a new variety of sulphur. If this conclusion is correct, it should be possible to obtain some information in the absence of sulphur chloride. This is actually the case, for if sulphur is heated alone to 125° and rapidly cooled, and its solubility in sulphur chloride examined, it is found that the solubility is distinctly greater than that of the unheated rhombic sulphur.

T. S. P.

273. *Relation between the Sulphur Modifications.* H. L. de Leeuw. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 584-598, Nov. 28, 1912.)—If the sulphur contained in a dilatometer tube is heated to its boiling-point, and then rapidly cooled so that a large proportion of the S_{μ} formed remains intact, it is found that the temperature of conversion of rhombic into monoclinic sulphur is lowered from 95.45° to about 71° . As the proportion of S_{μ} present decreases, the transition temperature rises until it reaches 95.45° , which must be regarded as the true unary transition point. Krüy's work [Zeitsch. Elektrochem. 10. p. 581, 1912] on the dynamic allotropy of sulphur is criticised adversely, and it is shown that there is no evidence for the assumption of a region of partial miscibility in the liquid phase. The occurrence of two liquid layers is due to differences in temperature, and when the thermal conductivity is increased by the introduction of Pt wire or gauze, the phenomenon in question is only observed very indistinctly or not at all.

T. S. P.

274. *Limit of Formation of Endothermic Compounds at very high Temperatures.* E. Briner. (Comptes Rendus, 155. pp. 1149-1151, Dec. 2, 1912.)—According to the principles of chemical equilibria, endothermic compounds become more stable with rise in temperature. It follows that compounds such as the oxides of nitrogen, ozone, carbon disulphide, etc., should exist in

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greater and greater concentrations as the temperature rises. This, however, would contradict the results of spectrum analysis, which proves the elementary nature of substances existing in the hottest stars. The contradiction is done away with when the dissociation of the molecules of elementary substances into their atoms at high temperatures is taken into account. Taking the values for the heat of formation of molecules from atoms as found for various elements by different observers, the author shows that compounds said to be endothermic become exothermic at temperatures sufficiently elevated, and their concentration reaches a maximum and diminishes with further rise in temperature. Taking the case of nitric oxide, and applying van t'Hoff's equation, $(d \log_e K)(dT) = -Q/(RT^2)$, it is shown that when the temperature is sufficiently high for the molecules of oxygen and nitrogen to be completely dissociated, the concentration of the nitric oxide will diminish with rise in temperature.

T. S. P.

275. Influence of Oxygen on the Properties of Metals and Alloys. E. F. Law. (Inst. of Metals, Journ. 8. pp. 222-230; Discussion and Correspondence, pp. 231-247, 1912. Engineering, 94. pp. 439-441, Sept. 27; Discussion, p. 448, Oct. 4, 1912.)—Draws attention to the great influence exerted by oxygen when present in metals and alloys. Although recognised by practical men, the scientific side of this question has been neglected. It is pointed out that a chemical analysis of copper which failed to report 0.1 per cent. of lead would be considered unsatisfactory, yet it frequently happens that 10 times this quantity of cuprous oxide is not reported. This omission is more serious than it appears at first sight, because the oxides, having lower specific gravities than the metals, occupy a larger volume and the influence exerted by an impurity depends upon its volume and not upon its weight. From cases examined, it would appear that metallic oxides are insoluble or practically insoluble in metals and alloys and occur as particles varying in size and distribution, entangled and embedded in the metal. Photomicrographs are given illustrating the presence of oxides in bearing bronze, arsenical copper from a locomotive fire-box, and also a series to show the effect of increasing additions of arsenic to oxidised copper. As regards the effect of the presence of oxides on mechanical tests, the minimum effect is produced when the oxide occurs in the massive form and the max. effect when the oxide occurs as a network between the crystals. Abnormal corrosion of metals, as also pitting and local deterioration, etc., is in most cases due to the presence of non-metallic impurities, and in all investigations of corrosion the presence of oxides must be taken into account.

C. O. B.

276. Alloys of Aluminium and Zinc. W. Rosenhain and S. L. Archbutt. (Inst. Mech. Engin., Proc. No. 2. pp. 319-441; Appendix and Discussion, pp. 441-515, April-May, 1912. Tenth Report to the Alloys Research Committee. Engineering, 98. pp. 578-579; Discussion, pp. 547-548, April 26, and pp. 615-618, May 10, 1912. Abstract. Mech. Eng. 29. pp. 487-490, April 19, 1912. Summary.)—These alloys have been investigated on the general lines of the Eighth and Ninth Reports [Abstract Nos. 1711 (1907), 1540 (1910)] and their constitution has already been described [Abstract No. 1611 (1911)]. The alloys are easy to cast, machine easily, and those containing in the region of 25 % Zn have a remarkable ring when struck. In discussing the results of tensile tests the authors have introduced

the quantity "specific tenacity," which is obtained by dividing the ultimate strength in tons per sq. in. by the weight of a cubic inch in lbs., to allow of correct comparisons between the strength of materials of widely different specific gravities. Tensile tests of both sand and chill castings reveal maxima at 50 and 75 % Zn, the latter corresponding to the compound Al_3Zn_3 . The highest stresses are 18.9 tons in the 75 % sand casting and 21.6 tons in the 50 % chill castings. Yield-points are very uncertain. Ageing tests carried on over 18 months showed no tendency towards loss of strength. The behaviour of the alloys under compression is similar to that under tension, but the chill castings are decidedly inferior to sand castings below 50 % Zn. Microstructures indicated an early tendency towards a cored formation which was observed at 5 % Zn in the chilled alloys. The rapid increase of the strength of zinc by the addition of small quantities of Al is explained by the early formation of the hard and strong Al_3Zn_3 . Hot rolling was not found possible on alloys containing over 26 % Zn. On rolling into sheets 0.07 in. thick the alloys up to 15 % Zn behaved well, but the 20 % alloy developed cracks at the edges. All the rolled and cold-drawn alloys possessed yield-points almost as well defined as that of steel. A remarkable fact is that in alloys containing over 17 % Zn, work beyond that required for rolling down from 8-in. billets to 1½-in. bars actually reduces the ultimate stress, while the yield stress is increased. The best mechanical tests are given by the 26 % Zn alloy in the form of a 1½-in. hot-rolled bar, which showed a yield stress of 25 tons, an ultimate stress of 27.09 tons per sq. in. and an elongation of 25 %. The beneficial effects of work persisted after annealing, and microscopic examination indicates that the tensile strength of annealed material is not strictly proportional to crystal size, but is proportional to the severity of working. Tests made at high temperatures indicate a rapid loss of strength with increase of temperature, but the rate of loss diminishes with increasing zinc-content. Although an alloy containing 20 % Zn shows an elongation of 180 % at 595° C., forging tests above 500° C. show an entire lack of malleability and the existence of extreme brittleness under shock. Elastic tests give a modulus of 9×10^6 lbs. for the alloys. Under torsion the 20 % Zn alloy shows a max. strength of 20 tons with an angle of twist of 810°. Under dynamic stresses the alloys containing 20–25 % Zn behave remarkably well, showing a range of stress of about 12 tons under Stanton's alternating stress test. The energy absorbed in fracture under the Izod test is about 5.8 lbs. for the 20 % alloy. Comparison of the various dynamic and static tests indicates that while strength is the determining factor in Stanton's test, ductility is the most important factor in Arnold's test, and the Izod test gives a curve representing the sum of strength and elongation. The results of all the mechanical tests indicate that the best combination of properties is to be found in the 20 % Zn alloy. Corrosion tests in the sea for a period of over 500 days indicate that the corrodibility of the alloys varies from 1½ times that of Naval brass to 1½ times that of Muntz metal according to the zinc-content, with increase of which the rate of corrosion increases. A ternary alloy containing 25 % Zn, 8 % Cu, and 72 % Al has also been studied. Although somewhat sensitive to rolling temperatures, this gives remarkable static and dynamic tests when properly treated. Hot-rolled material shows a yield stress of 22 tons per sq. in., an ultimate stress of 28–31 tons per sq. in., and an elongation of 16.5 %. In the *discussion*, Donaldson confirmed the deleterious effect of excessive working. Archbutt quoted tests which showed that alloys made from pure Zn are decidedly superior to those made

from spelter, both as regards strength and ductility. The coefficient of expansion of the 20 % alloy is 0.000284, a value which is about double that of steel.

F. C. A. H. L.

277. Method of Producing Sound Ingots. R. Hadfield. (Iron and Steel Inst., Journ. 86. pp. 11-39 ; Discussion and Correspondence, pp. 48-77, 1912. Engineering, 94. pp. 477-488, Oct. 4, 1912.)—By soundness in ingots is meant freedom from piping, blowholes, and segregation, and experience teaches that as a rule the means of removing one defect tends to diminish the others. The various methods of fluid compression are all more or less successful, but require costly apparatus. In the author's method the steel is poured into a mould, preferably small end downwards, and immediately covered with a layer of slag $\frac{1}{4}$ in. in thickness. Charcoal is then placed on the slag and burnt by means of jets of compressed air. In this way the top of the ingot is kept fluid, and solidification takes place from the bottom upwards. The paper is illustrated by numerous diagrams and photographs of ingots and the rails rolled therefrom, showing that with the exception of only about 8 per cent. waste, the whole of the ingot is free from piping and segregation, so that 92 per cent. of the metal poured into the mould can be utilised, thus effecting a saving of 8s. to 12s. per ton.

F. C. A. H. L.

278. New Method of revealing Segregation in Steel Ingots. R. Hadfield. (Iron and Steel Inst., Journ. 86. pp. 40-47 ; Discussion and Correspondence, pp. 48-77, 1912. Engineering, 94. pp. 484-485, Oct. 4, 1912.)—The method consists of pouring a small quantity of molten copper on to the top of the ingot soon after pouring. If the copper is added before solidification is complete it displaces the residual molten steel, but if added after complete solidification it fills up the cavities and indicates the areas of segregation. The method appears to open up a valuable source of information on the rates of cooling, segregation, and liquation, and the present results indicate that the interior of an ingot remains hotter for a much longer period than has previously been thought, thus providing greater opportunities for segregation to take place.

F. C. A. H. L.

279. Use of Thermit for obtaining Sound Steel Ingots. H. Goldschmidt. (Iron and Steel Inst., Journ. 86. pp. 78-87 ; Discussion and Correspondence, pp. 88-90, 1912. Engineering, 94. pp. 485-486, Oct. 4, 1912.)—The method formerly adopted of pushing a thermit cartridge through the crust and into the pipe of a partially solidified ingot in order to melt the surrounding metal, did not have the desired effect. Latterly, however, the cartridge has been pushed right down to the bottom of the ingot before solidification commenced. The vigorous reaction which sets in immediately brings about an energetic agitation of the contents of the mould, expelling the liberated gases and driving the segregate upward. After the reaction has subsided, considerable subsidence of the metal takes place, which is followed up by pouring in fresh metal from the ladle. The new method has proved very efficacious, especially in the case of non-siliconised steel. A saving of 1s. 6d. per ton is effected on the rolled material, which also possesses the great advantage over untreated steel of showing greater uniformity in mechanical properties.

F. C. A. H. L.

280. Pre-rolled Pipeless Ingots. B. Talbot. (Eng. News, 68. pp. 957-958 ; Discussion, pp. 958-959, Nov. 21, 1912.)—The author describes

a new process for the prevention of segregation and piping in ingots. Aluminium is added to the fluid steel (2 oz. per ton) to prevent the formation of external cavities and the resulting ingot is reduced about 25 per cent. by rolling before complete solidification. The partially reduced ingot is then allowed to completely solidify in a soaking pit before rolling is completed. In steel treated in this way the segregated area is confined to an annular ring between the centre and the outside, these being quite normal in composition, except that the carbon is somewhat low in the central portion, which appears to be an ideal condition for the production of rails. In the *discussion*, **Webster, Stevenson, and Kenney** pointed out the difficulties arising from rolling ingots at too high a temperature; these include internal rupture, the development of cross cracks, and squirting out of the metal. F. C. A. H. L.

281. Measurements and Relations of Hardness and Depth of Carbonisation in Case-hardened Steel. **M. A. Ammon.** (Amer. Inst. Mining Engin., Bull. 70. pp. 1167-1179, Oct., 1912.)—Samples of low-carbon and case-hardening nickel steel (8.80 per cent. Ni) were carbonised at 1650° and 1750° F. for various times. Subsequently specimens were quenched in various ways, after which the depth of carbonisation was determined microscopically and the hardness by both Shore and Brinell methods. In the Brinell method a 0.25-in. diam. ball was used under a load of 5000 lbs. The hardness number was calculated from the formula $B = 44700/D$, where B is the standard Brinell number and D the depth of penetration in ten-thousandths of an inch. The results show that the rate of carbonisation is about $1\frac{1}{4}$ times as fast at the higher as at the lower temperature, and about 1.1 times as fast in ordinary case-hardening steel as in Ni steel. In the quenched specimens the scleroscope hardness shows a gradual decrease with increasing depth of case, owing to the increase of the amount of austenite in the surface. The Brinell figures are somewhat irregular, but show a general increase up to a carbonising period of 4 to 6 hours, after which the hardness is stationary. This is in accordance with the fact that the scleroscope gives surface hardness, while the Brinell figure depends upon the condition of the core. When double quenching is adopted, the Brinell hardness after the second or low-temperature quench is always less than the figure obtained after the first or high-temperature quench for small depths of case. As the depth of case increases, the core has less and less influence on the determination of the hardness, whose value then rises until it is the same after the second as after the first quenching. This occurs at a depth of case of about 0.11 in., thus providing a method of estimating the depth of the case. F. C. A. H. L.

282. Iron-Carbon and Iron-Silicon Alloys. **E. Gumlich and P. Goerens.** (Faraday Soc., Trans. 8. pp. 98-114, Oct., 1912. Communication from the Physikal.-Techn. Reichsanstalt.)—An extensive series of tests has shown that the presence of large amounts of silicon prevents, even with rather quick cooling, the formation of the extremely injurious solid solution of carbon and iron: the carbon appears only in the shape of the much less injurious pearlite. Under the influence of the Si, even the pearlite is decomposed by a prolonged process of annealing into ferrite and temper-carbon, and thus becomes magnetically almost entirely passive. To produce this effect with certainty at least from 8 to 4 per cent. of Si is necessary in the material. The fact that thin sheet-metal containing carbon and less than 8 per cent. of Si may show exceedingly good magnetic properties must have other reasons. A. D. R.

283. Iron and Nitrogen. J. H. Andrew. (Iron and Steel Inst., Journ. 86. pp. 210-226; Correspondence, pp. 227-285, 1912. Abstracts in Engineer, 114. p. 424, Oct. 18, 1912. Engineering, 94. pp. 860-862, Dec. 20, 1912.)—The author has designed a high-pressure electric furnace capable of melting iron and of withstanding pressure up to 1000 atmos. It was shown that iron and iron-carbon alloys absorb small quantities of nitrogen when melted in the gas under high pressure. The presence of 0.8 % nitrogen in pure iron entirely suppresses the critical changes, while 0.25 % in 0.6 % carbon steel causes a marked lowering of the A_1 point. Prolonged heating *in vacuo* is required to remove the nitrogen. The author is of opinion that the critical changes occurring in iron are due to the coalescence of like molecules brought about by contraction during cooling. The intervention of nitride of iron hinders this coalescence, with the result that a greater contraction is required before the molecules are brought sufficiently close for the molecular attractions to exert themselves. Hydrogen has no effect on the critical changes.

F. C. A. H. L.

284. Coarse Crystallisation Produced by Annealing Low-Carbon Steel. R. H. Sherry. (Metallurgical and Chem. Engin. 10. pp. 666-667, Oct., 1912.)—The production of large crystalline grains in low-carbon steels by annealing at 650° to 690° C. is often observed in the manufacture of sheets and plates, but efforts to produce the structure at will in the laboratory are not invariably successful. Experiments made by the author confirm some of the earlier observations of Stead and Charpy. Steels containing 0.07 to 0.11 % C, 0.0 to 0.075 % Si, 0.02 to 0.04 % S, 0.008 to 0.05 P and 0.05 % Mn were annealed for periods up to 48 hours. It was necessary to heat for 45 mins. to obtain the growth, but the increase was not continuous with the time. Hammered pieces showed no tendency to crystalline growth on subsequent annealing at 700° C. if the hammering was stopped just above 700° C., but if continued below 700° C., crystalline growth took place on subsequent annealing. Cold-worked material also showed a tendency to grow if the work done was light. If the reduction had been 9 to 7 per cent. crystalline growth took place at 690 to 775° C., but if over 9 per cent. reduction had been effected, growth occurred between 650° and 875° C. on re-annealing. The max. growth observed was from 0.02 to 0.8 mm. diam. of grain.

F. C. A. H. L.

285. Generation of Large Grains in Metals. F. Robin. (Comptes Rendus, 155. pp. 716-718, Oct. 14, 1912.)—Stead and Charpy showed long ago that the annealing of mechanically hardened steel results in the development of very large grains making the metal fragile. Recent studies have shown this to be the case with other metals. In the area affected by a local deformation the max. growth of the grains is prevented by mutual interference, but on the borders of the area considerable growth takes place and the grains extend into the unaffected parts. The temperature and duration of the preliminary annealing and the size of the grains obtained thereby do not appear to influence the final results. Extension of the large grains into the undeformed parts from a centre of deformation caused by punching, shearing, bending, etc., follows the ordinary annealing laws. Maximum growth takes place at a certain temperature which differs for each particular metal. The author has determined the max. growth and distance of propagation of the grains of Sn, Pb, Zn, Al, Cu, and Fe, and quotes actual measurements; the results being of technical importance because of the large number of

objects made from sheet metals by cold working and annealing. Evil effects can be overcome by a final heating to above 900° C. in the case of iron and the addition of foreign elements to the other metals. F. C. A. H. L.

286. Case-carbonising. M. T. Lothrop. (Amer. Soc. Mech. Engin., Journ. 84. pp. 1997-2070, Dec., 1912.)—Elaborate experiments have been carried out to determine the effects of temperature, time, and composition of steel on the depth, rate, and nature of carbonisation and the effect of heat-treatment on the finished product. Mild steels, nickel steels, chrome-nickel, and chrome-vanadium steels were used in the tests, and the physical properties were determined by placing a bar 12 in. long and $\frac{1}{4}$ in. diam. on 10-in. centres, loading at the centre, and observing the load and deflection at rupture. Strength and toughness decrease with increasing depth of case, and there is a critical depth of case for max. brittleness and minimum strength, which depth depends upon the original carbon-content of the steel. The higher the original carbon-content of the steel, the smaller the ratio of depth of case to diam. of core at the point where this brittleness occurs. Double heat-treatment increases both strength and toughness, which is also increased by subsequent tempering at 880° F. Annealing after carbonising is not to be recommended, as it does not improve the properties to anything like the same extent as double quenching, and, further, there is a distinct danger of decarbonisation. Carbonised steel becomes file-hard at temperatures too low for the development of max. strength and properties. The ideal treatment is to carbonise to the thinnest possible case demanded by the conditions, reheat for core 1600° F., quench, reheat to 1500° F. for case, quench in water or oil, and finally temper as far as conditions of service permit. Chrome-vanadium steel does not lose its file-hardness until a temperature of 450° F. has been reached, while the other steels mentioned can be softened at 425° F. Gears treated in this way can be made harder, stronger, and tougher than oil-hardened gears. With increase of temperature both the depth of carbonisation in a given time and the carbon-content of the case increase. Uniform penetration cannot be obtained below 1500° F. Nickel steel gives the greatest total penetration and gradation zones, while chrome-vanadium steels give the highest carbon maximum and the finest-grained steel. The original carbon-content does not affect either the depth of case or the amount of carbon introduced by the carbonising agent. Below 1400° F. the carbon maximum does not exceed the eutectic, but as the temperature rises a hyper-eutectic zone is formed which increases in depth with the temperature. A surface content of over 1 per cent. carbon results in the existence of films of carbide existing between the grains and gives rise to flaking. On the other hand the case does not develop its max. hardness below 0.9 per cent. carbon. In pieces to remain unground, therefore, practice should aim at a 0.9 per cent. carbon surface, but in specimens which are to be ground the surface content should be somewhat higher. An important factor in determining the temperature of carbonising is the grain-growth under the influence of heat, which is not affected by the presence of nickel but is seriously diminished in rate by the presence of Cr and V. Experiments were also made to determine the efficiency of 14 carbonising materials bought in the open market, and the results show that there is a considerable variation in the density of such materials. All of them shrink and become less potent on use. The ideal carbonising material, which should show large volume per ton, small shrinkage per run, high resistivity to change of shape or powdering, cleanliness and freedom from dust, uniform carbonising power, and capability of

being used an innumerable number of times, is yet to be found. Generally speaking the thermal conductivity of carbonising materials increases with use. Copper-plating can prevent carbonisation, but the thickness of deposit must be at least 0.0005 in. to be effective. Microscopic examination of all the samples was made, and the results show that the effect of double quenching is to refine the martensitic structure of the material.

F. C. A. H. L.

287. Solubility of Metallic Oxides and Sulphides in fused Sodium Chloride. **H. Houben.** (*Metallurgie*, 9, pp. 592-600, Sept. 18, 1912.)—The sodium chloride from Stassfurt, containing 98 per cent. of NaCl, was fused in Morgan clay crucibles; ordinary clay crucibles and carbon and graphite vessels proved unsuitable. The fused salt began to solidify at $820 \pm 8^\circ \text{C}$., which agrees with Ruff and Plato. The experiments were made in kryptol or, better, in Helberger furnaces, the metal compound being added to 40 gm. of NaCl, of which considerable quantities evaporated, especially above 1000° , when dense white vapours escaped. Of the compounds tried, SnO_2 , ZnO , PbO , CuO , ZnS , PbS , Cu_2S , only small quantities (in no case as much as 1 per cent.) were dissolved by sodium chloride, which cannot therefore be recommended as a solvent for electrometallurgical purposes.

H. B.

288. Electrical Conductance of Solutions in Methylamine and Ethylamine; Fluidity of Ammonia, Methylamine, and SO_2 , and Fluidity of certain Solutions in these Solvents. **F. F. Fitzgerald.** (*Journ. Phys. Chem.* 16, pp. 621-661, Nov., 1912.)—The abnormal conductivity-dilution curves given by solutions in methylamine and ethylamine have been further investigated, together with the viscosities and densities of the solvents ammonia, methylamine, and SO_2 , and a number of their solutions. Solutions of silver nitrate and potassium iodide in methylamine at -88.5° , -15° , 0° , and $+15^\circ$ have a max. molecular conductivity at about normal concentration, followed by a minimum at $n/40$, and then a progressive rise on further dilution. There is no evidence that the molecular conductivity tends to approach a max. value at high dilutions as in the case of aqueous solvents of these substances. The results obtained with a number of other inorganic salts are similar in character. In ethylamine as solvent, solutions of silver nitrate, ethylammonium chloride, and lithium chloride show only the max. conductivity at about normal concentration. The molecular conductivity shows no tendency to increase again, after attaining a minimum, even at high dilutions. The temperature-coefficient of conductivity of solutions in methylamine and ethylamine changes sign on passing from concentrated to dilute solutions, as is the case also with certain solutions in sulphur dioxide and ammonia. The solvent and ionising properties of the amines are related to those of ammonia as the properties of the alcohols to those of water. On ascending the homologous series of solvents the ionising power and the solvent action on metallic salts decreases, but the solvent action on carbon compounds increases. The viscosities of the solutions measured decrease progressively on dilution. The viscosities, η , of the pure solvents methylamine, ammonia, and sulphur dioxide were measured. The values of the product $\eta\Lambda_\infty$, where Λ_∞ is the molecular conductivity of potassium iodide at infinite dilution, lie between 0.9 and 1.1 with ammonia and SO_2 , whereas with normal solvents Walden obtained the value 0.65. Ammonia and SO_2 must therefore be regarded as abnormal in the same sense as water is abnormal.

T. S. P.

289. Conductivity, Temperature-Coefficients of Conductivity, and Dissociation of Certain Electrolytes in Aqueous Solution at 85° , 50° , and 65° . **S. F. Howard**

and **H. C. Jones**. (*Amer. Chem. Journ.* 48. pp. 500-586, Dec., 1912.)—In continuation of earlier work on the same subject [see Abstracts Nos. 1745 (1911), 102 (1912)] the molecular conductivities of the following salts and acids have been measured, and the temperature coefficients and percentage dissociation calculated: Sodium ferrocyanide, potassium carbonate, potassium permanganate, dipotassium hydrogen phosphate, potassium sodium sulphate, potassium chromium sulphate (violet and green), potassium nickel sulphate, ammonium chromium sulphate (violet and green), calcium bromide, calcium chromate, zinc nitrate, zinc acetate, lead chloride, lead acetate, nickel acetate, uranyl chloride, nitrate, sulphate and acetate, hydrochloric acid, nitric acid, and sulphuric acid. Double salts in general have smaller conductivities than the sum of the conductivities of the constituent salts. These differences are little affected by temperature but become less with greater dilution. Certain discrepancies occur between the results published in this paper and those of other workers, as, for example, in the case of the alums and of dipotassium hydrogen phosphate. These are due to the fact that the hydrolysis varies with the time; the time factor is greater for concentrated than for dilute solutions, and is very little affected by the temperature. The discrepancies may also be due to decomposition occurring, with the formation of new substances. The observation is confirmed that salts with large amounts of water of crystallisation possess large temperature-coefficients. For salts which do not undergo hydrolysis the temperature-coefficient increases with the dilution. The violet forms of ammonium and potassium chrome alum have smaller conductivities than the green forms, but the differences become less at higher temperatures. With the exception of uranyl acetate and dipotassium hydrogen phosphate there was a decrease in the percentage dissociation with rise in temperature. After standing for four weeks the phosphate acted normally.

T. S. P.

290. Molecular Association in Gases. J. de Boissoudy. (*Comptes Rendus*, 155. pp. 704-706, Oct. 14, 1912.)—Starting from the assumption that two molecules of a gas impinging one on the other subsequently remain associated when the relative velocity of their translatory motion does not reach a certain value dependent only on the nature of the molecules, the author derives the following equation of state: $(p + ac^{2/3}/v^2T^{1/2})(v - b) = RT$, where a and b are constants. This equation, which is of the type of Clausius' equation, gives at constant volume values of the function, $\pi = T \cdot \partial p / \partial T - p$, in satisfactory agreement with the recent determinations of Leduc, the product πT diminishing at first and becoming sensibly constant only at temperatures above the critical temperature.

T. H. P.

291. Vapour Pressure of Concentrated Aqueous Solutions. E. P. Perman and T. W. Price. (*Faraday Soc.*, *Trans.* 8. pp. 69-81; Discussion, pp. 82-85, Oct., 1912.)—(1) Measurements have been made of the vapour-pressures of solutions of urea, glycerol, cane-sugar, potassium chloride, calcium chloride, and raffinose over a very wide range of concentrations, and at different temperatures. (2) The lowering of the vapour-pressure has been found to be proportional to the concentration, except for very high concentrations. (3) Babo's law has been found to hold in some cases. (4) Hydration, when present, is not fixed, but is a function of the concentration.

L. H. W.

292. Fractionation by Diffusion; Application to Colloidal Solutions. Part I. **S. Dabrowski.** (*Acad. Sci. Cracovie, Bull.* 6a. pp. 485-526, VOL. XVI.—A.—1918.

June, 1912).—A new diffusion-apparatus has been devised in which diffusion takes place under constant conditions and in the absence of convection-currents. In the case of solutions of urea of different concentrations the product of the coefficient k multiplied by the viscosity η of the liquid is constant at a given temperature; Einstein's formula may therefore be used for interpolation. The values of the diffusion-coefficient are, however, lower than those determined in the ordinary way by the method of "free diffusion." The coefficient of diffusion of crystallised ovalbumen, diffusing in solutions of ammonium sulphate, is lower than that of the dialysed albumen dissolved in pure water. By means of Einstein's formula it is possible to calculate the volumes of the molecules from the diffusion-coefficient and the viscosity; the molecular volume of ovalbumen in 8.6% ammonium sulphate was thus shown to be six times less than in the absence of salts.

T. M. L.

293. *The Mutual Association of Ether and Chloroform in the Gaseous State.* F. Dolezalek and A. Schulze. (Deutsch. Phys. Gesell., Verh. 14. 24. pp. 1091–1096, Dec. 80, 1912).—It has previously been shown [see Abstract No. 781 (1912)] that in the case of mixtures of ether and chloroform in the liquid state the deviations which are met with from the law of mixtures can be explained by assuming the formation of a partially dissociated compound of the two substances. The authors have investigated the behaviour of the substances in the gas state, in order to see whether any evidence was to be found of a similar association. The method which they employed was to find out whether there was any change of volume when the unsaturated vapours were mixed. When the vapours were mixed it was found that contraction occurred, pointing to the fact that combination occurred even in the gaseous state. Moreover, from the amount of contraction the authors calculated that in a molecular mixture of ether and chloroform at 80° and under a pressure of 1 atmo. compound-formation occurs to the extent of 0.64 molecule per cent. Further, by the application of the law of mass action it follows that the combination between ether and chloroform increases almost proportionally with the total pressure: so that in the saturated vapours, at 80°, combination takes place to the extent of 1.4 molecules per cent. It follows therefore that in the liquid state compound-formation also occurs, and it is calculated that the liquid phase contains 14.6 molecules per cent. of the compound.

A. F.

294. *Dissociation of Some Oxides, Carbonates, and Sulphides.* W. Hempel and C. Schubert. (Zeitschr. Elektrochem. 18. p. 729, Aug. 15, 1912. C. Schubert's Dissertation, Techn. Hochschule, Dresden).—A table of observations made by determining the volume of gas generated in an electric furnace at temperatures measured by a le Chatelier pyrometer. The table gives the temperatures of the beginning and the end of the dissociations for some ores (manganese dioxide, hematite, spathic iron ore, pyrites of iron and copper, magnesite, etc.), and some compounds (PbO, permanganate, nitrates, chromates).

H. B.

295. *The Potential of Tantalum.* G. v. Hevesy and R. E. Slade. (Zeitschr. Elektrochem. 18. pp. 1001–1002, Nov. 15, 1912).—Owing to the instability of the aqueous solutions of their salts, the potentials of tantalum, vanadium, etc., are still uncertain. W. v. Bolton [Abstract No. 1098 (1905)] placed tantalum between Pt and Ag. The authors experiment with the metal and its pentafluoride TaF₅, polarising the metal both anodically and

kathodically to overcome the passivity difficulty. In the passive state the potential is about 1 volt higher than that of silver, in the active state nearly the same as that of copper.

H. B.

296. Combustion Galvanic Cells. E. Baur and H. Ehrenberg. (*Zeitschr. Elektrochem.* 18. pp. 1002-1011, Nov. 15, 1912. H. Ehrenberg's Dissertation, Zürich.)—The cells consist of U-tubes of porcelain, heated to 1000° by a coil. The lower portion contains fused silver; a nickel wire dips into the one limb; the other contains over the silver the electrolyte, generally within a short tube of porcelain to protect the walls of the U. Into the electrolyte dips the other electrode, a carbon rod, or tubes of Pt, Fe, Ni, Cu; hydrogen or CO is introduced into this limb, oxygen is blown into the other. The electrolytes are carbonates and metasilicates of K and Na in mixtures, cryolite and alumina, and chiefly borax; sodium metaphosphate did not answer for some obscure reason. The other electrolytes resembled one another in their behaviour and yielded about 1 volt against the Ag-O electrode. In larger-scale experiments the silver was melted in a porcelain crucible and oxygen blown into it; a magnesia crucible above the silver contained the electrolyte and carbon tubes, the whole being heated within a tubular furnace. These cells had internal resistances of less than $\frac{1}{4}$ ohm, gave nearly 1 volt on open circuit and were free from polarisation after working for several hours at comparatively large current outputs. Several of the other combinations also yielded nearly the theoretical volts.

H. B.

297. Silver Nitrate-Acetone Concentration Cell. A. Roshdestwensky and W. C. McC. Lewis. (*Chem. Soc., Journ.* 101. pp. 2094-2099, Nov., 1912.)—The experiments mentioned in Abstract No. 417 (1912) are continued with a very sensitive Lipmann capillary electrometer, the concentration cells containing silver nitrate in acetone. When the nitrate is exposed to sunlight for a day, a brown precipitate is formed, but the e.m.f. is not measurably affected. Nernst's formulæ being found applicable, the transport number of the anion of silver nitrate in acetone at 19° would range from 0.60 to 0.56 for concentrations ranging from 0.02-N to 0.007-N and less. The liquid/liquid potential can no more accurately be eliminated by the interposition of ammonium acetate, than it could in the previous experiments by lithium nitrate; the validity of middle-liquid methods for acetone solution appears doubtful.

H. B.

298. Temperature-variation of the Conductivity of Aluminium Anode-films. G. E. Bairsto. (*Faraday Soc., Trans.* 8. pp. 282-251; Discussion, p. 252, Oct., 1912.)—The law previously found by the author [Abstract No. 619 (1912)], that the leakage currents of Al anode-films vary with temperature according to $i = Ae^{\alpha\theta}$, is confirmed for many electrolytes (ammonium borate, phosphate, dicarbonate, molybdate, acetate), and seems to have a general meaning. The α is independent of the formation voltage, the time of formation, the concentration of the electrolyte and the kathion; it depends only on the anion being a definite function of the equivalent weight of the anion in solution, and may serve for determining this quantity. For a given formation voltage, α decreases with the voltage of the test; but when a certain current density is reached (the same for all test voltages), the conductivity increases more rapidly than according to the formula. The A varies widely with the different factors. For voltages up to about half the formation voltage

the resistance of the film is practically constant; then it falls off rapidly. The ammonium dicarbonate forms an exception because it is decomposed at 55° C.; this shows already at 55°.

H. B.

299. *Electrolysis in Liquefied Sulphur Dioxide.* L. S. Bagster and B. D. Steele. (Faraday Soc., Trans. 8. pp. 51-67, Oct., 1912. Chem. News, 105. pp. 157-160, April 4, 1912. Elektrochem. Zeitschr. 19. pp. 241-246, Dec., 1912.)—During the electrolysis of solutions of potassium iodide, sodium iodide, tetramethylammonium iodide and trimethylsulphonium iodide in anhydrous, liquid sulphur dioxide, sulphur is deposited at the kathode, a sulphite being formed at the same time. At the anode, changes occur which are analogous to those occurring in aqueous solution; for example, bromine and iodine are liberated from solutions of bromides and iodides. Anodes of zinc and iron are attacked and pass into solution as complex iodides when iodides are electrolysed. Investigation of a solution of both hydrogen bromide and water in liquid SO₂ showed that water is carried to the kathode during electrolysis, which is evidence in favour of the formation of an oxonium compound between the water and the hydrogen bromide, which is electrolytic in character. This evidence was strengthened by comparison with the behaviour of several well-known oxonium compounds, for example, dimethylpyrone. A few electrode potentials of metals (Pb, Zn, and Cd) immersed in a saturated solution of their salts (chloride, bromide, and iodide) were measured at -85° and found to give remarkably constant values, as follows:—

Pb | PbCl₂ | Hg₂Cl₂ | Hg = 0.485 volt;

Zn | ZnBr₂ | Hg₂Cl₂ | Hg = 0.87-0.40 volt;

Cd | CdI₂ | Hg₂Cl₂ | Hg = 0.42-0.445 volt.

The mercury electrode is negative in the first two cases. Owing to the extremely small capacity of the cells it was necessary to use a quadrant electrometer in making the measurements.

T. S. P.

300. *The Lead Sulphide Electrode and the Passivity of Lead.* P. P. Lebedew. (Zeitschr. Elektrochem. 18. pp. 891-896, Oct. 15, 1912.)—The original measurements of Bernfeld on the lead sulphide electrode [see Abstract No. 540 (1898)] having given values which are in total disagreement with the known solubility of lead sulphide, the author has repeated them, using exactly the same method as Bernfeld. His results are in very good agreement with those of Bernfeld. The disagreement mentioned above is due to the fact that the lead-sulphide electrode is not really a reversible one of the second kind. Exactly the same values for the e.m.f. are obtained when a Pt electrode replaces the lead in a solution of sodium hydrosulphide, that is, when there is no lead in the cell. Lead sulphide is thus to be considered as an indifferent electrode in this solution, that is, lead behaves as a passive metal in solutions of sodium hydrosulphide. The fact remains, however, that a Pb or Pt electrode has a perfectly definite potential in solutions of sodium hydrosulphide saturated with hydrogen sulphide, although further experiments are necessary to determine what the electrode process is.

T. S. P.

301. *Iodine Coulombmeter and the Value of the Faraday.* E. W. Washburn and S. J. Bates. (Amer. Chem. Soc., Journ. 84. pp. 1841-1868, Oct., 1912. Paper read before the 8th Internat. Congress of Applied Chemistry, Sept., 1912.)—A review of the work which has hitherto been done on the

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silver, copper, iodine, and oxyhydrogen coulombmeters indicates that the silver coulombmeter gives too low a value for the faraday, but is superior to all the other types in reproducibility. The authors have endeavoured to obtain an iodine coulombmeter which should equal the silver coulombmeter in reproducibility, and be free from all sources of error amounting to more than 0.001 %. The apparatus devised consists essentially of two vertical limbs connected by a V-tube, and furnished with electrodes of Pt-Ir foil. It is filled with 10 % potassium iodide solution to a little above the level of the V-tube, and then a concentrated solution of potassium iodide is layered beneath the solution in the anode limb, whilst a solution of iodine in potassium iodide is similarly layered in the kathode limb. A comparison of the amount of iodine liberated at the anode with the amount which disappears at the kathode shows that within the limits of error in analysis the same quantity of iodine is formed from iodide ions at the anode as is converted into iodine ions at the kathode. The coulombmeter is free from any constant source of error amounting to more than 0.002 %, and the reproducibility of the reaction at the anode fulfils the requirements necessary for a trustworthy determination of the faraday within 0.005 %. The iodine coulombmeter was then compared with the silver coulombmeter and applied to the determination of the faraday, the mean value of which was found to be 96,524 coulombs per equivalent ($I = 126.92$), the electrochemical equivalent of iodine being 1.81491 mgm. per coulomb. If the ratio of Ag to I as found by Baxter is employed instead of the international atomic weights, the results give 1.11755 for the electrochemical equivalent of silver. [*Errata*, *ibid.* p. 1515, Nov., 1912.]

T. S. P.

302. *Influence of Acid Concentration on the Chemical Polarisation of the Reversible Electrode Cu/Cu⁺*. D. Reichinstein, A. Bürger, and A. Zieren. (Zeitschr. Elektrochem. 18. pp. 850-864, Oct. 1, 1912).—The polarisation observed when a metal is anodically dissolved or cathodically deposited is not a concentration polarisation, but of chemical nature, since it may assume values of a higher order. The polarisation involves two phenomena: the primary current flow, due to the absorption or liberation of electrons, is practically instantaneous; the secondary process is subject to chemical inertia (Haber). The concentration of the free acid in the electrolyte exerts an influence [see Abstract No. 1629 (1911)]. The authors deduce from the general equation for the polarisation a relation between current density and the concentration which determines the polarisation. The quantitative experiments demonstrate that, for the reversible electrode Cu/CuSO₄, both the cathodic and the anodic polarisation diminish with increasing acid concentration; the acid concentration was varied between 0.0188-N and 2.188-N. The same rule holds for the cathodic polarisation of Cd/CdSO₄. The quotient of current density J and acid concentration ($c = x$): $J/x = y$, can be expressed as a hyperbolic function $y - a = b/x$, the constants of which have been determined by the method of mean squares. On the other hand J is $ac + b$, which is a linear relation, but the straight line does not pass through the origin of the co-ordinates. The current density is hence greater than zero when the acid concentration is zero. The phenomena seem to depend upon two quantities, only one of which is dependent upon the acid concentration; this is explained by reference to chemical kinetics, and an expression is found for the asymptotic value of the polarisation which is independent of time. H. B.

303. *Passivity of Iron under Boiler Conditions*. H. G. Byers and F. T. Voris. (Amer. Chem. Soc., Journ. 84, pp. 1868-1879, Oct., 1912.) [See VOL. XVI.—A.—1918,

Abstract No. 2065 (1908).]—The suggestion has been made by Cushman that small quantities of inhibitive substances in boilers should be highly efficacious in preventing pitting. The authors have studied the effect of potassium dichromate, the temperatures used approaching those prevailing under steam-boiler conditions. In all cases the electrochemical method of investigation was used. It is found that an iron anode is rendered passive by dichromate solutions of concentration as low as 0.125 per cent., and is kept passive, even when the anodic current is very small, at all temperatures ranging from room temperature to those approximating boiler conditions (160°). In the presence of moderate quantities of sodium chloride the concentration of dichromate required to maintain the passive state is approximately 40 times greater at room temperature; 25 times greater at 98°, and 40 times greater at 125°–150°. The authors can offer no explanation of this peculiar behaviour. When sodium sulphate is present in moderate concentrations, an equal concentration of dichromate is sufficient to ensure passivity of the anode at temperatures up to 150°. The presence of carbonates and bicarbonates in water seems to have no destructive effect on passivity induced by dichromate. From these results it seems probable that since the percentage of chlorides in boiler water is usually small, the addition of an amount of dichromate 40 times that of the chlorides present, calculated as sodium chloride, plus that needed to precipitate the scale-forming substances, would be of much value as a boiler preservative. The doubtful factor in the above experiments is, however, the extent to which the results have been influenced by the anodic current. Experiments are therefore being carried out to ascertain how long iron will remain unruined in such inhibitive solutions in the absence of the electric current.

T. S. P.

304. *Electrolytic Formation of Dichromate from Chromate.* E. Müller and E. Sauer. (Zeitschr. Elektrochem. 18. pp. 844–847, Oct. 1, 1912).—The electrolysis of sodium chromate yields more dichromate than alkali in diaphragm cells. The authors use iron as cathode in sodium hydrate and a Pt cylinder as anode in sodium chromate contained in a clay cylinder. The reason of the anomaly is that within the pores of the diaphragm the lye becomes three times as concentrated in free alkali as in the much larger space near the cathode, and this should always take place, when the cathode stands in alkali and the anode in a neutral salt.

H. B.

305. *Electrolytic Method for the Prevention of the Corrosion of Iron and Steel.* J. K. Clement and L. V. Walker. (Electrician, 70. p. 182, Nov. 1, 1912. Paper read before the Internat. Congress of Applied Chemistry, 1912).—The authors have investigated the influence of (a) rate of stirring the electrolyte, (b) amount of oxygen in the electrolyte, and (c) acid concentration, on the corrosion of steel. A counter e.m.f., depending upon these factors, can prevent corrosion and the current density required can be calculated from the loss of weight of the metal under the given conditions when not protected and the electrochemical equivalent.

F. C. A. H. L.

306. *The Law of Molecular Attraction.* J. E. Mills. (Phil. Mag. 24. pp. 488–500, Oct., 1912).—The author discusses *seriatim* some of the divergences found, and shows that these were not due to the inaccuracy of his equation.

L. H. W.

307. *Constitution and Melting-points of Copper-slugs.* C. H. Fulton. (Amer. Inst. Mining Engin., Bull. 72. pp. 1457-1486, Dec., 1912.)—Gives freezing- and melting-curves and tables of composition and melting-point; also full details of the thermoelectric method employed. L. H. W.

308. *Fundamental Properties of the Equation of State.* R. D. Kleeman. (Phil. Mag. 24. pp. 391-401, Sept., 1912.)

309. *Extension of the Theory of Allotropy, Monotropy, and Enantiotropy for Liquids.* A. Smits. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 861-871, Oct. 24, 1912.) [See Abstract No. 1279 (1912).]

310. *Contribution to the Theory of the Binary Systems. XXI. Condition for the Existence of Minimum Critical Temperature.* J. D. van der Waals. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 602-614, Nov. 28, 1912.)

311. *Calculation of the Thermodynamic Potential of Mixtures, when a Combination can take place between the Components.* J. J. van Laar. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 614-620, Nov. 28, 1912.)

312. *Solubility and Supersolubility from the Osmotic Standpoint.* Berkeley. (Phil. Mag. 24. pp. 254-268, Aug., 1912.)—Mainly a theoretical discussion from the thermodynamic standpoint. L. H. W.

313. *The Knowledge of Liquid Mixtures. I.* R. B. Denison. (Faraday Soc., Trans. 8. pp. 20-47; Discussion, pp. 47-50, Oct., 1912.)—Unsuitable for brief abstraction. The author attempts to devise a more definite way of deciding upon possible association between mixed liquids. L. H. W.

314. *Elimination of Potential due to Liquid Contact. II.* A. C. Cumming. (Faraday Soc., Trans. 8. pp. 86-98, Oct., 1912.)—A continuation of the work dealt with in Abstract No. 548 (1907) the present paper being concerned with the equation for calculation of diffusion potential.

SCIENCE ABSTRACTS.

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ERRATUM.

Abstract No. 266, line 8 : *for* Lune, *read* Laue.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1913.

GENERAL PHYSICS.

315. *Koschwitz Rectangular Glass Plate.* K. Lüdemann. (Zeitschr. f. Vermess. 41. p. 801, 1912. Zeitschr. Instrumentenk. 82. p. 888, Dec., 1912.)—Describes a glass plate made by Koschwitz, of dimensions 18 cm. \times 18 cm., and on which is a rectangular network of lines 1 mm. apart, covering a space 11 cm. \times 16 cm. The plate is intended to be used in measuring areas, and results may be obtained with it correct to about 1 in 1000. A. W.

316. *Electrical Measurement of Periodic Phenomena.* G. Lippmann. (Comptes Rendus, 155. pp. 1458-1460, Dec. 28, 1912.)—In place of the usual method for the comparison of two periodic phenomena by coincidences, an electrical contrivance is described which permits of at least as great accuracy, and at the same time is more rapid and is applicable to other problems where the method of coincidences is unsuitable. The apparatus is very simple, consisting merely of a rotating metallic arm carrying current to two contacts whenever it touches them. These contacts can be moved independently round the path of the rotating arm. Putting a telephone in series, one of these contacts is adjusted so that the sound of the contact is synchronous with one of the timepieces to be compared. Then the other contact is adjusted to be in time with the second timepiece. The path of the rotating contact is graduated, and the difference of angle between the two contacts, taken in relation to the known period of rotation of the central arm, gives the difference between the two timekeepers. The adjustment may be made to one-hundredth of a second. C. P. B.

317. *Determination of Poisson's Ratio.* I. Williams. (Phil. Mag. 24. pp. 886-891, Dec., 1912.)—In these experiments a steel beam of cross-section 2.49 cm. \times 0.498 cm. is subjected to a uniform bending moment which causes its mean line to assume a longitudinal curvature $1/R$. Then the cross-section assumes a transverse curvature, $1/R_1$, such that $R/R_1 = \sigma$, σ being Poisson's ratio (= lateral contraction/linear elongation). The longitudinal curvature is measured optically by a mirror fixed to the beam over one knife-edge. This

mirror was found to give accurately one-half of the curvature, a mirror on the other end being unnecessary. The first method of measuring R_1 was by attaching two mirrors opposite each other to the vertical sides of the beam. The relative angular movement of the sides is measured by the difference of the mirror scale-readings. The readings are interpreted by the relation $\sigma = \text{const. } D_1/D$, where D_1 and D = deflection on transverse and longitudinal scales respectively. With this method of attachment the scale of D_1 is only $\frac{1}{10}$ of that of D ; 8 values for σ were obtained lying between 0.265 and 0.280, mean value 0.278. To magnify the scale of D_1 a bifilar mirror suspension is used, a mirror being suspended by silk fibres from arms soldered to the sides of the beam and bent twice at right angles. The mirror is damped by a vane immersed in oil and protected from draughts by a case. The transverse scale is thus magnified in the ratio ($= 20$) of the height of the points of suspension above the beam to the distance between the threads. The 8 values of σ thus obtained vary from 0.2909 to 0.2982, mean value 0.2922. The max. difference from the mean is 0.44 %. E. J. S.

318. *Mechanical Properties of Solids and Liquids.* A. Mallock. (Roy. Soc., Proc. Ser. A. 87. pp. 466-478, Dec. 18, 1912.)—A paper discussing the various unclassified mechanical properties distinguished by the adjectives: Hard, soft, brittle, friable, tough, ductile, malleable, plastic (applied to solids); hard, soft, fibrous, granular, smooth (applied to surfaces); mobile, oily, viscid, frothy (applied to liquids). It is shown that all the above properties can be explained by the relations between (i) the absolute values of resistance to change of volume and change of shape, (ii) the volume limits and shear limits, (iii) forces belonging to the boundary surfaces (surface tension in liquids and forces of the same nature in solids). A. W.

319. *Stress Distribution and Manner of Failure in Sand Foundations.* O. Strohschneider. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 299-386, Feb., 1912.)—Boussinesq has, from a consideration of potential in a body loaded at one point, obtained expressions for the horizontal and vertical components of stress at any point in the interior. These expressions are independent of the elastic constants for the material, so that it has only to be homogeneous in structure without of necessity being elastic. The present paper describes the direct determination of stresses in loose sand. The pressure is transmitted by a diaphragm placed at any desired point to a manometer. The latter is of the constant-level type, as a direct-reading instrument was found to allow sufficient movement to cause subsidence in the sand, vitiating the results. The vertical components observed are found to be consistently higher than those of Boussinesq, showing that, since their sum must in all cases equal the applied load, the stresses in sand do not extend to infinity on all sides of the loading axis. The author hence deduces an expression for the stress at any point by introducing into the analysis of Boussinesq the hypothesis that at any given depth below the load there is a range, subtending at the loading point with the axis an angle ϕ_0 , beyond which there is no stress. The tests show that this expression is of the correct form for any given depth, but that ϕ_0 increases progressively with the depth, so that the envelope of the limiting ranges is a solid of revolution about the loading axis, whose surface is asymptotic to a horizontal plane at a depth H , below which the material becomes homogeneous and obeys the theoretical relations. It is found that $\sin \phi_0 = \rho_h/\rho_H$, where ρ_h and ρ_H are the densities of the sand at depths h and H , ρ_H being that of rammed sand.

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Further, the increase of density ρ_h over ρ_0 , that at the surface, varies as the weight of overlying sand $\int_0^h \rho_h dh$. The angle ϕ_0 is found by substitution of observed stresses in the empirical formula and ρ_0 , ρ_h , and ρ_H are measured directly, whence H is calculated. For lightly packed sand foundations the limiting angle ϕ is found to be 50° – 60° , H being about 1 m. Sand, like rigid bodies, will only withstand stressing up to a certain point, beyond which the subsidence suddenly increases. The resistance increases very rapidly with the area over which the load is distributed, varying as the third power of the diam. when a circular plate is employed. The resistance is also greatly increased by pouring on sand above the loading plate. In the equation of Boussinesq the stress varies inversely as the square of the distance from the load, from which it follows that at moderate depths the stresses, and hence the resistance, tend to become nearly constant. The results obtained confirm this tendency; with very thin layers of sand the influence of the underlying support is very noticeable, so that the resistance falls to a minimum at about 1.5 cm., then rises in a flat curve, which becomes nearly horizontal at 6 cm. Since sand is usually used to reinforce a weak subsoil it is necessary to proportion the depth of the former so that the latter shall not be overstressed, by using the empirical relation obtained. In a homogeneous elastic material, if σ_x and σ_z are the principal stresses, due to its own weight, at any point then $\sigma_x/\sigma_z = 2f^2 + 1 \mp 2f\sqrt{f^2 + 1}$, where f = the coefficient of internal friction, gives the condition for failure by shear slip. An analysis is made of the stresses on a material in these limiting conditions which are set up on the application of a single-point load. It is shown that approximately the principal stresses at any point lie along and perpendicular to the line joining the point to the application of the load. The lines of slip are plotted for these cases for a value of $f=0.7$ corresponding to an angle of repose of 85° . The intermediate case for a perfect fluid, when $\sigma_x = \sigma_z$ is also plotted, giving a series of concentric circles. Photographs of a section of loose sand during progressive loading show definite slip-lines obeying some law intermediate to those investigated, but rammed sand is not so satisfactory, this being attributed to the difficulty in ramming uniformly.

E. J. S.

320. Determination Optically of Stress Distribution. E. G. Coker. (Nature, 90, pp. 888–886, Dec. 5, 1912.)—The nature of stressing in simple structural members is now well known; but in most cases still to be investigated the stresses vary enormously from point to point. The author's well-known method of using the temporary double-refracting properties of stressed glass has enabled the stress at a point to be measured exactly. Glass is now replaced by one of the nitrocellulose compounds which is nearly as perfect optically, is not so fragile, and is much stronger in tension. With plane-polarised light the lines of principal stress are deduced from the map of isoclinic bands; hence the exact stress-distribution on the minimum section is set out. With circularly-polarised light the isoclinics are absent, enabling the colour-fringes indicating stress to be observed more accurately and to be calibrated from a wave-length or a colour scale. A zero method, which is easily manipulated, is to set a simple tension member along one principal axis and to stress it until the field is black at the required point. In many cases, e.g. the minimum briquette section, the minor principal stress is relatively small, and the experimental curve of principal stress-differences represents truly the end stresses, and those at other points nearly. The mean

minor principal stress is given by the difference between the mean height of this curve and the mean applied load stress. A very large polariscope, designed by the author and S. P. Thompson, is described. Light from a bank of lamps is diffused by tissue-paper and reflected by a black glass plate, set at the polarising angle, on to quarter-wave plates arranged to produce a circularly-polarised field. A thin glass plate analyser serves for qualitative, and a small nicol for quantitative work. This apparatus is used for models of ships and structures and has a clear field of 8 ft. \times 1 ft. The results are shown for a long thin plate subjected to shear [see Abstract No. 776 (1912)]. The case of a conventional eye-bar is considered, a better design being suggested. The colour-fringes in a pair of spur wheels transmitting a heavy torque are also shown. E. J. S.

321. Elastic Deformation of Water Conduits. G. Colonnetti. (Accad. Lincei, Atti, 21. pp. 826-834, Sept. 22, 1912.)—Calculates the deformation of a water main when just filled, but not under pressure. Shows that the tube assumes an elliptical section, the dilatation of which is only half what it would be if the average hydrostatic pressure were distributed uniformly. This difference becomes less as the pressure is increased. E. E. F.

322. Predetermination of the Stresses which will arise in Structures. Mesnager. (Comptes Rendus, 155. pp. 1071-1072, Nov. 25, 1912.)—Describes the application to scale models of the well-known method of calibrating stresses in members of glass placed normal to a ray of plane-polarised light. The making of pieces such as I-beams by cutting from the solid glass is difficult and expensive, and causes unavoidable internal stresses which even annealing will not remove. If the components are cut from sheet and melted together residuary temperature stresses cannot be eliminated. The author has successfully used gelatine made soluble at the ordinary temperature to join the strips of carefully annealed glass. The cement is transparent and does not interfere with the optical properties of the glass. The slipping resistance, 0.5 kg. per sq. mm., is sufficient. Internal stresses in the models are very small, and their effect may be eliminated by using an unstressed model as datum. The points and magnitudes of max. stress, and the most unfavourable load-configuration were found in this way, with a model of scale 8 mm. to 1 m., for a bridge of 97 m. span with the arch encasté and partly solid with the deck. E. J. S.

323. Mechanical Hardening without Deformation. Hanriot. (Comptes Rendus, 155. pp. 1502-1504, Dec. 23, 1912.)—It has been shown previously that under certain conditions [see Abstracts Nos. 151, 825 (1918)] stretching may diminish mechanical hardness in spite of the fact that it increases the deformation. In order to study the possibility of hardening mechanically without deformation, a piece of annealed silver was compressed between two pistons in a cylindrical hole in a steel block. The silver squeezed out showed that the deformation only amounted to about 0.65 per cent., but the superficial hardness was increased from 23.5 to 39.5. In the centre the hardness was 38.7, but in spite of this uniformity the impression made by the ball was slightly oval. At the same time the strength had increased from 8.8 to 10.6 kg. per sq. cm. and the elongation had dropped from 18.8 to 10 per cent. Nevertheless, the specimen was slightly deformed, and consequently cubes of Ag, Cu, Al, Fe, brass, and Zn were subjected to a hydrostatic pressure of 10,000 kg. per sq. cm. All showed considerable signs of hardening, but VOL. XVI.—A.—1918.

under the microscope the crystals were not deformed. Therefore mechanical hardening may be effected merely by compression without change of structure, and in itself is due to the deformation to which the metal has been subjected and not to the process of hardening. F. C. A. H. L.

324. Hardness of Coins. T. K. Rose. (Nature, 90. pp. 835-836, Nov. 21, 1912.)—The hardness defined as the resistance to permanent deformation is of the greatest importance in the process of minting, and is most readily determined by the Shore scleroscope. An annealed sovereign blank has a hardness of 25.5, which is increased to 50-58 on being struck. A sixpence has a hardness of 50, while a florin shows a value equal to 87. These values refer only to the "table" or flat portions of the coins, the raised portions of the design being much softer. In minting, the force of the blow appears to be expended almost wholly in the surface layers so that the centre of a coin is almost as soft as annealed metal. As a result the rate of wear increases during circulation. Tests have shown that the gold and silver trial-plates of the mint have, in the course of centuries, become almost completely softened at the ordinary temperature. The rate of softening is increased rapidly as the temperature rises. Softening is accompanied by a recrystallisation brought about by a change in the orientation of the molecules *in situ*. Gradual growth of the crystals occurs subsequently without much further softening. F. C. A. H. L.

325. Stretching of Metals. Hanriot. (Comptes Rendus, 155. pp. 971-974, Nov. 11, 1912.)—The indications of the physical state of a metal given by "ball hardness" are imperfect because of the modifications introduced by the pressure of the ball. Ingots of silver, brass, and aluminium have been cut into plates which were carefully annealed and rolled to various thicknesses in order to get various degrees of cold-working. Hardness tests and tensile tests were then made, after which the hardness was again determined close to the point of fracture. The results show that feebly-worked metals show almost the same tensile strength and elongation for all degrees of working although the hardness increases considerably with the degree of working. After a certain degree of working the strength increases rapidly. Up to this point, tests made after fracture show an increase of hardness, but above this degree of working, the stretch accompanying a tensile test actually diminishes the hardness. It would appear, therefore, that study of the tensile strength and elongation does not give all the information required about the physical state of a metal. They can, however, indicate whether or not a certain degree of working has been put upon the metal. Further tests on a 9 per cent. Al bronze, brass, and Al, show that mechanical hardening on stretching, as measured by increase of ball hardness, does not occur until the metal has been subjected to a permanent deformation. F. C. A. H. L.

326. Elastic Hysteresis of Steel. B. Hopkinson and G. T. Williams. (Roy. Soc., Proc. Ser. A. 87. pp. 502-511, Dec. 18, 1912. Engineering, 94. pp. 827-828, Dec. 18, 1912.)—Tests were made on steel with Hopkinson's alternating-stress machine and extensometer [see Abstract No. 628 (1912)]. The specimen is subjected to steady cyclical stress-variation of constant magnitude and within the elastic limit. The rise of temperature of the middle of the length over the ends, due to dissipation of energy by elastic hysteresis, becomes steady after 5 minutes' running and is observed by a

thermo-couple galvanometer coupled up by constantan wires. By averaging readings both ways external heat effects, such as those of eddy currents, are eliminated. The fall is about 10 deg. C. under 28 tons' range, and readings are correct to $\frac{1}{100}$ deg. C. Calibration is effected by passing alternating current through the specimen as it is held in the machine, the extensometer being removed. Simultaneous readings of a suspended-coil watt-meter, showing the energy dissipated over the effective length, and of the thermo-couple galvanometer enable the latter to be calibrated direct in ergs per cm.² or in degrees of temperature, the former being most useful. Hysteresis losses at the higher stresses obtained at various times check to within 2 % to 8 % and increase roughly as the fourth power of the range. The loss under 89 kg. per sq. mm. (25,000 ergs per cm.² per cycle) is of the same order as the magnetic loss in fairly strong fields. In neither case is any cumulative change in the properties of the material evident. Such a change is expected to be accompanied by a rise in the rate of energy loss but this is not found in the present tests at the highest range (45 kg. per sq. mm.) after $\frac{1}{4}$ million reversals in $\frac{1}{4}$ hour, though Stanton's results for the same metal indicate fracture after less than 100,000 reversals at 20 per sec. Hence it is concluded that there is some permanent effect which is negligible at high speeds. The existence of the elastic hysteresis stress-strain loop is demonstrated by a static test. The alternating-stress specimen is reduced to a cyclical state by alternate loading in tension and compression through the range, e.g., 10 tons. The length is measured just after releasing 10 tons' compression, and then after applying and releasing 10 tons' tension; the difference is the intercept of the loop on the axis of strains. Assuming that the loop is lenticular and made up of arcs of circles, its area is $\frac{2}{3} \times \text{length-difference} \times \text{range}$. The hysteretic stress-difference (= length-diff. \times E) is calculated on this assumption from the work per cycle as measured in the high-speed tests and is plotted against the range, being found to bear a nearly constant ratio, 0.8, to the statically determined difference. The ratio depends on the factor for the loop area, being 0.58 and 1.0 respectively for the limiting values, 1 and 0.5, of the latter. It is concluded that the hysteresis in cycles at 120 per sec. is less than in static tests but by not more than 80 %. The latter measurements are made with a modified Ewing extensometer having a tilting mirror. A control specimen was submitted to tensile load instead of compressive before taking the first reading. A second reading taken after the application and removal of the same tensile load showed a difference usually unmeasurable and never more than 10 % of that due to a full cycle from tension to compression. Hence the results show hysteresis effects truly to within 10 % or $\frac{1}{100}$ ton per sq. in. E. J. S.

327. Theory of Beams. Hisely. (Comptes Rendus, 155, pp. 953-956, Nov. 11, 1912.)—A vertical force, P , applied to a beam supported in any manner whatever, produces an effect e_P which may be a bending longitudinal thrust, or shear, causing a linear or angular displacement in any direction. If x be the abscissa of P 's point of application and $y = F(x)$ be the equation of displacements for unit force, then $e_P = PF(x)$. A moment M , replacing P , is replaced by equal forces, P' and P'' , acting in opposite senses at points x and $x + \delta x$, where δx is small, and $M = P'\delta x$. Then $e_{P'} = -P'F(x)$ and $e_{P''} = P'F(x + \delta x)$, from which: $e_M = e_{P'} + e_{P''} = MF'(x)$. This relation means that the equation to displacements due to unit moment is given by the first differential of that for unit force. It is convenient to take the origin at one support, A , of a span $AB = l$ on which P acts at a distance $x = al$. Then
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$e_P = Plf(a)$ and $e_M = Mf'(a)$. If the beam be free at A and supported in any manner at B, then $T_P = Plf(a)$ is the angular deflection at A. A moment M at A causes a deflection $T_M = Mf'(0)$. If the beam be now encastré at A, $T_P + T_M = 0$ and $M_A = -Plf(a)/f'(0)$ is the necessary moment. If T_P occurs at the end B, supposed free, then the moment for encastration at B is $M_B = -Plf(a)/f'(1)$. These formulæ enable an arc, articulated at the ends, to be encastré at both or one end. In a freely supported straight beam of constant section the slope of one end B is $T_P = Plf(a) = Pl \cdot l/6EI(a - a^3)$. Then $M_B = \frac{1}{3}Pl(a - a^3)$. The theory is then applied to the continuous beam.

E. J. S.

328. Space-Time Manifold of Relativity: The Non-Euclidean Geometry of Mechanics and Electromagnetics. E. B. Wilson and G. N. Lewis. (Amer. Acad., Proc. 48. No. 11. pp. 389-506, Nov., 1912.)—It is the purpose of this work to develop the four-dimensional non-Euclidean geometry which is demanded by the principle of relativity, and to show that the laws of electromagnetics and mechanics not only can be simply interpreted in this way, but also are for the most part mere theorems in this geometry. In the early sections the non-Euclidean geometry in two dimensions is developed in some detail and applications to problems in kinematics and mechanics are given. The sections on three dimensions are occupied largely with analytical developments of the vector algebra. Certain vectors of singular character are also considered. Passing to the case of four dimensions, further new types of vectors are met with and the new differential operator *quad* \diamond is used.

The science of electromagnetics is treated both from the point of view of the point charge and from that of continuous distribution. In both cases it is shown that the field of potential and the field of force are merely the geometrical fields previously mentioned except for a constant multiplier. Particular attention is given to the field of an accelerated electron, and here it is found that the vectors of singular properties play an important rôle. By a general treatment it is then shown that the conservation laws of momentum, mass, and energy are special deductions from a single general law stating the constancy of a certain four-dimensional vector or vectors of *extended momentum*. Finally it is pointed out that this last vector gives rise to geometric vector fields which can be identified with the fields of gravitational potential and gravitational force. Moreover it is shown that these fields are identical in mathematical form with the electromagnetic fields.

E. H. B.

329. Linear Space-time Transformation. K. Kraft. (Acad. Sci. Cracovie, Bull. pp. 952-968, Dec., 1912.)—The author considers an aggregate of all possible space-time co-ordinate systems, fulfilling only the condition that in each of them all the others appear in constant translatory motion. Concludes, without any further assumptions, that on suitably choosing the origins and units, each pair of systems conforms to the identity—

$$\epsilon(x_1^2 + y_1^2 + z_1^2) - t_1^2 = \epsilon(x^2 + y^2 + z^2) - t^2,$$

where t is constant throughout the aggregate. He does not decide as to the sign or magnitude of ϵ , and avoids Einstein's postulate of the constancy of the speed of light.

E. E. F.

330. Uniform Rotation and Relativity. J. W. Nicholson. (Phil. Mag. 24. pp. 820-827, Dec., 1912.)—In this paper, a formal examination is made of
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the limits within which a correlation (as to rectilinear and rotational motions and the relativity principle) can be obtained on the ordinary analytical lines. It thus appears that a second-order correspondence cannot be found, so that the geometry of uniform rotation cannot be expressed in a simple general way. This is not an unexpected result, since rotation involves acceleration in a variety of directions, and the case of uniformly accelerated motion in one direction has not yet been so expressed. E. H. B.

331. *Theory of Gravitation*. M. Abraham. (N. Cimento, 4. Ser. 6. pp. 459-481, Dec., 1912.)—A more elaborate statement of the author's new theory of gravitation [see Abstract No. 785 (1912)]. He abandons Einstein's original postulate of the constancy of the velocity of light c , and considers it variable with the gravitational potential. In fact, he enunciates as his first postulate that the negative gradient of c indicates the direction of the gravitational vector. This postulate is shown to be implied in the equations of Lagrange. The second postulate maintains that "an observer belonging to the material system observed cannot ascertain any change in c . This means that the duration of any occurrence varies inversely as c , but does not exclude, for instance, the displacement of the sun's spectrum lines towards the red owing to its gravitational potential. Such a displacement has often been observed, but attributed to solar atmospheric currents or pressure." A third postulate says that "the forces acting on two bodies in equal gravitational fields are as their energies." This combines the conservations of mass and of energy into one law. Length is independent of c , and so is action, but mass varies as c^{-1} , as does time; and hence energy and force vary as c .

Newton's law is inexact. It should contain a term inversely proportional to the cube of the distance, but in astronomy this term is negligible. E. E. F.

332. *Theory of Gravitation*. G. Pavanini. (Accad. Lincei, Atti, 21. pp. 648-655, Nov. 3, 1912.)—In Abraham's gravitational theory [see preceding Abstract] rigorous equations are given which have, however, a functional character depending on motions previous to the acceleration of two bodies. The author gives equations correct to the second order of the observation constant which have no functional complexities, and which bring out the difference between a propagation with the velocity of light and an instantaneous propagation. This difference takes the form of terms involving the inverse square of the velocity of light, and additional terms depending on the various elements of motion. E. E. F.

333. *Hayford Method of Gravity Reduction*. W. Bowie. (Washington Acad. Sci., Journ. 2. pp. 499-504, Dec. 19, 1912.)—The new method of reduction introduced by Hayford is based on the assumption that the earth's crust is in a state of approximate equilibrium called *isostasy*. The deficiency of density or material in the earth's crust under the land, and the excess under the oceans, is called the *isostatic compensation*. This compensation occurs, or is supposed to occur, within the upper portions of the earth's crust, and the depth to which it extends is called the *depth of compensation*. From the first investigation the most probable value for this depth was found to be 113.7 km. The 124 gravity stations in the United States have been arranged in groups according to the character of the topography surrounding the stations. The results indicate that there is no appreciable relation between the character of the topography and the gravity anomaly, and they also indicate that the earth's crust, under each class of topography, is in a state of

approximate equilibrium. Comparisons are then made between Hayford's reduction and the formulæ by Helmert; one of the tests is the value of the polar flattening of the earth as derived from stations in a limited area. This comes out as $1/298.8$, which is in close agreement with other determinations.

C. P. B.

334. Relativity Principle and Law of Central Forces. Lémery. (*Comptes Rendus*, 155. pp. 1005–1008, Nov. 18, 1912.)—A mathematical paper deducing the inverse-square law for central forces due to electric charges from the principle of relativity. It is stated that for Euclidean space of n -dimensions the law would involve the $(n-1)$ power in agreement with what we know for tri-dimensional space. But this ordinary space is the only one in which there can exist a law of force satisfying the admitted principles, and a substance of which the density is proportional to the divergence of this force. [See Abstract No. 1112 (1911).] E. H. B.

335. A. Einstein's Theorem. E. M. Lémery. (*Comptes Rendus*, 155. pp. 1224–1227, Dec. 9, 1912.)—In studying the case of a source of light which moves with respect to the observer, A. Einstein showed [see Abstract No. 188 (1906)] that the mass of the body diminished when it radiated energy. The present author gives a calculation leading to the result that the total energy radiated by a symmetrical radiator is the same, whether or not it is displaced relative to the observer. E. H. B.

336. Geographical Position of Mecca and Yidda. N. Scheltema. (*Konink. Akad. Wetensch. Amsterdam, Proc.* 15, pp. 527–572, Nov. 28, 1912.)—Mecca is an important starting point for the study of Arabian geography, but accurate observations of its position have for long been impossible owing to religious difficulties. The present author, Consul for the Netherlands at Jidda, the harbour of Mecca, arranged for the necessary astronomical observations to be made in the sacred city by a young Mohammedan student, A. Salém. Circummeridian altitudes were observed at Mecca and Jidda, and these observations, together with chronometer readings, compared with the British Hydrographic survey values of Jidda. Resulting position of Mecca (Kabah) is $\phi = +21^{\circ} 25' 18.4''$; $\lambda = 39^{\circ} 50' 59.2''$ (2h. 39m. 28.95s.), east of Greenwich. C. P. B.

337. Determination of Relative Gravity in Tunis and Malta. A. Venturi. (*Accad. Lincei, Atti*, 21. pp. 548–561, Nov. 3, 1912.)—Determinations of the value of g at three stations in Tunis, and in Malta, show that it is very slightly less than at Palermo, the results being Palermo, 980.086; Tunis, 979.955; Biserta, 979.998; Nabeul, 979.898; and Valletta, 979.905. W. H. St.

338. Brownian Motions and Probability Law. R. v. Ettenreich. (*Akad. Wiss. Wien, Ber.* 121. 2a. pp. 1168–1187, July, 1912.)—The theory of molecular collisions lies at the root of the derivation of the law of Brownian motions given by Einstein and Smoluchowsky [see Abstract No. 1909 (1905)]. This derivation handles the problem as a statistical one and treats it by the law of probability. In the present experimental determination an emulsion of mercury in water was adopted. The suspended particles were thus sure to be spherical, and their high density ensured their speedy passage out of the way. The chief conclusions are as follows:—(1) The distribution of the displacements corresponds to the probability law. (2) The mean square of displacement.

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ment is, within the limits of error, proportional to the displacement time, which accords with the assumption of a statistical source of the phenomena.
 (8) The vertical displacements are distinctly less than the horizontal ones.
 (4) The mean value of Loschmidt's number is $N = 82.8 \times 10^{23}$. E. H. B.

339. Application of Fourier's Theorem to Physical Problems. Rayleigh. (Phil. Mag. 24. pp. 864-869, Dec., 1912.)—Deals with the difficulties arising in practical applications owing to an unnecessary degree of precision. Thus, in reflection, the aggregate reflection may be put $= C + iS$, where

$$C = \int_{-\infty}^{+\infty} \phi(v) \cos uv dv, \quad S = \int_{-\infty}^{+\infty} \phi(v) \sin uv dv \dots\dots\dots (4)$$

with $u = 4\pi/\lambda$.

In the converse problem we regard the reflection as given for all values of u and we seek thence to determine the form of ϕ as a function of x . By Fourier's theorem we have at once—

$$\phi(x) = \frac{1}{\pi} \int_0^{\infty} du [C \cos ux + S \sin ux] \dots\dots\dots (5)$$

It will be seen that we require to know C and S separately. A knowledge of the *intensity* merely, viz. $C^2 + S^2$, does not suffice.

Although the general theory, above sketched, is simple enough, questions arise as soon as we try to introduce the approximations necessary in practice. For example, in the optical application we could find by observation the values of C and S for a finite range only of u , limited indeed in eye observations to less than an octave. If we limit the integration in (5) to correspond with actual knowledge of C and S , the integral may not go far towards determining ϕ . It may happen, however, that we have some independent knowledge of the form of ϕ . For example, we may know that the medium is composed of strata each uniform in itself, so that within each ϕ vanishes. Further, we may know that there are only two kinds of strata, occurring alternately. The value of $\int \phi dx$ at each transition is then numerically the same but affected with signs alternately opposite. This is the case of chlorate of potash crystals in which occur repeated twinings. Information of this kind may supplement the deficiency of (5) taken by itself. If it be for high values only of u that C and S are not known, the curve for ϕ first obtained may be subjected to any alteration which leaves $\int \phi dx$, taken over any small range, undisturbed—a consideration which assists materially where ϕ is known to be discontinuous.

E. E. F.

340. Basis of a Theory of Matter. G. Mie. (Ann. d. Physik, 40. 1. pp. 1-66, Dec. 31, 1912.)—This is the third and concluding paper of a series on this subject [see Abstracts Nos. 782 (1912) and 18 (1913)]. It deals with the relation between inertia and weight, with the problem of the working quantum (*Wirkungsquantum*), and with gravitation. The analysis is four-dimensional and vectorial, but a few results may be noted. (1) Inertia mass and weight mass (*träge Masse und schwere Masse*), of a body are only completely identical when its elementary particles do not execute any internal motions. Hidden motions of these particles effect an increase of the inertia and a decrease of the weight. (2) The ratio of weight mass to inertia mass, consequently the so-called gravitation constant, is for every material a function of the tempera-

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ture, which decreases with a rise of temperature. (8) The change of the gravitation constant with temperature is different in different materials, and is greater according as there is a greater part of the specific heat of the material corresponding to the kinetic energy of molecular motions. (4) Working at room temperatures, an experimental accuracy of 1 in 10^{11} or 10^{12} would be needed to detect the distinction between the values of the ratios, for different substances, of the weight and inertia. (5) The gravitation field is of one kind only and not of two as for magnetic and electric fields. (6) The interposition of one body does not affect the gravitational attraction of two others. (7) The motions of particles (or electrons) produce longitudinal ether waves or *gravitational radiation* (*Schwerestrahlung*), but at any frequency the intensity of such radiation bears to the corresponding light-intensity the ratio $1 : 8.3 \times 10^{49}$!

E. H. B.

341. Air-resistance. W. König. (Phys. Zeitschr. 18. pp. 1018-1016 ; Discussion, p. 1017, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—Describes with diagrams various pieces of apparatus for determining wind-pressure, etc. To produce the air-blast a large tapering tube was used, which had a fan in the larger end driven by a motor placed some little distance away and coupled to it by a flexible shaft. It was found that for plates perpendicular to the direction of the air-current the pressure was proportional to the square of the velocity, but not quite proportional to the area of the surface. A large plate of double the area of a smaller one did not quite experience double the pressure. A special apparatus was used to investigate the vertical component of the pressure experienced by an inclined plate. Three different wind-velocities were employed, and all show a decided asymmetry when the vertical component of the pressure is plotted against the angle of tilt of the plate. In all three cases the max. vertical pressure is found when the plate makes an angle of 80° to 82° with the horizontal. Another piece of apparatus is designed to investigate the position of the centre of pressure.

A. W.

342. Suction behind Ships. Poincet. (Comptes Rendus, 155. pp. 957-960, Nov. 11, 1912.)—A discussion of two series of experiments on a certain vessel shows that the results confirm those previously obtained in experiments on small models ; hence it is possible to solve completely the problem of propulsion for the case of vessels with two lateral screws by means of experiments with small models. Suction and the effect of the wake are considered, and it is shown how these affect the efficiency of screws ; the efficiency may, where cavitation does not take place, reach 70 %.

A. W.

343. Transition Layers and Surface Tension. R. D. Kleeman. (Phil. Mag. 24. pp. 876-885, Dec., 1912.)—It requires the expenditure of energy to produce an increase in the area of surface of a liquid. The surface tension is therefore the work done, keeping the temperature constant, in producing unit increase in the area of surface of the liquid. Now this increase of surface may be produced in a variety of ways, since it follows from thermodynamics that the work done during an isothermal process between given limits is independent of the nature of the path of the process. One way suggested by Laplace is to suppose a slab of liquid cut into two parts by an imaginary plane, and the parts then separated by an infinite distance from one another. If W denotes the total amount of work done during the process of separation, and A the amount of new surface formed, the surface tension λ , is given by

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$\lambda_1 = W/A \dots (1)$. If the distribution of the molecules in the new surfaces formed is the same as in the interior of the liquid, and the law of molecular attraction were known, the work done could at once be calculated. But the distribution of the molecules in the surface of a liquid is not the same as in the interior, a transition layer is formed in which the density changes continuously from that of the liquid on one side of the layer to that of the vapour on the other side. The nature of the effect of the formation of a transition layer on the surface tension can be easily investigated. Suppose that on separation of the two slabs of liquid in the foregoing process, no change takes place in the distribution of the molecules in the surfaces of the slabs. The work done, as before, is W . Now suppose the transition layers to be formed. This will require that the surface layer of the liquid undergoes expansion in different degrees in different parts. Since the complete process of increase of the surface of a liquid is a reversible one, we must suppose that the formation of the transition layer takes place in such a way that external work is done during the process, and that it is a reversible one. We may, for example, suppose that the liquid is contained in a cylinder in which the piston is in contact with the liquid surface in question exerting a pressure tending to prevent the formation of the layer. This work is done at the expense of the heat supplied since the temperature has to be kept constant during the process. Let w denote the amount of work in this case. The actual surface-tension of a liquid is then given by $\lambda_1 = (W - w)/A \dots (2)$. Thus we see that the production of a transition layer on the surface of a liquid has the effect of decreasing the magnitude of the surface tension.

A formula is developed in this paper which expresses W in terms of quantities which can be measured. Since λ_1 can also be measured, the value of w can be calculated by means of equation (2). E. E. F

344. Shape of Capillary Surface. A. Ferguson. (Phil. Mag. 24. pp. 887-844, Dec., 1912.)—A theoretical examination of the shape of the capillary surface formed by the external contact of a liquid with a cylinder of large radius. It is hoped to use the formulæ thus developed in subsequent experimental work. E. H. B.

345. Temperature Variation of Capillarity of Glycerine Solutions. J. Skala. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1218-1223, July, 1912.)—Following a new method, absolute measurements of the capillarity constant and its temperature-coefficient were made for various strengths of glycerine solutions. For pure glycerine a value was found for the capillarity constant of 68.89 dynes/cm. at a temperature of 18.8°C. The decrease of the constant with increase of the percentage of glycerine in solution does not follow a linear law. The temperature coefficient for pure glycerine is positive and decreases (within the limits of error) apparently proportionally with the percentage of water present until for a solution with 60 % glycerine (corresponding to a glycerine-water mixture containing 51.78 % recrystallised glycerine) the temperature-coefficient is zero, and the capillarity constant is independent of the temperature. Further addition of water gives the solution a negative temperature-coefficient. A. W.

346. Change of Surface Tension of Mercury by Metallic Amalgams. F. Schmidt. (Ann. d. Physik, 89. 6. pp. 1108-1132, Dec. 28, 1912.)—The surface tensions of pure mercury and of its amalgams were experimentally determined by Rayleigh's vibrating-jet method. The openings were of VOL. XVI.—A.—1918.

elliptical section and the waves occurring in the streams issuing from them were photographed and evaluated. The chief results may be summarised thus :—(1) The metals, Zn, Cd, Tl, Au, Sn, Pb, in the highest concentration tested, produced only a slight change in the surface tension of mercury. Zn, Cd, Tl increase the surface tension ; Au, Sn, Pb decrease it. (2) The metals Na, K, Rb, Cs, Li, Ca, Sr, Ba, even in small quantities, cause a great change in the surface tension. Li, Ca, Sr, Ba increase, and Na, K, Rb, Sc decrease the surface tension. The first traces of the alkali metals have no effect ; the greatest change occurs for a certain small concentration interval characteristic of each alkali metal. (3) The change produced in the surface tension of mercury is a periodic function of the atomic weight of the dissolved metal. (4) Metals occurring in the same group in the periodic system produce a change of the same sense. (5) For certain classes of metals, the higher the melting-point, the higher the surface tension of the amalgam.

E. H. B.

347. Bifilar Conical Pendulum Seismograph. C. Mainka. (Phys. Zeitschr. 18. pp. 1206-1212, Dec. 15, 1912. From a paper read before the 84. Naturforscherversammlung, Münster, 1912.)—Description, with illustrations, of a series of massively built conical pendulum seismographs, the smallest pattern carrying a weight of 185 kg., the largest 2000 kg.

C. P. B.

348. Work of the Reichsanstalt in 1911. (Zeitschr. Instrumentenk. 32. pp. 119-185, April ; 155-169, May, and pp. 195-210, June, 1912. Extract. Abstracts in Zeitschr. Elektrochem. 18. pp. 823-882, Sept. 15, 1912. Engineering, 94. pp. 766-767, Dec. 6, and pp. 802-804, Dec. 13, 1912.)—In the German report the work done in the various branches is reviewed ; in the English abstract, some of the more interesting developments, particularly as regards the electrical work are briefly described.

L. H. W.

349. Liquid Films and the Foaming of Solutions. S. A. Shorter. (Phil. Mag. 24. pp. 629-682, Oct., 1912.)—Gives an outline of a mathematical theory of the elasticity of liquid films which it is hoped may throw light on the process of foaming. [See Abstracts Nos. 189 (1907) and 1621 (1912).]

E. H. B.

350. Gyrostatic Action. J. W. Milnor. (Phys. Rev. 35. pp. 477-488, Dec., 1912.)—Mathematical treatment of a general problem in gyrostatic action which includes the cases recently treated by Franklin and by B. L. Newkirk. [See Abstracts Nos. 469, 1484, 1808 (1912).]

E. H. B.

351. Equilibrium of the Circular-arc Bow-girder. A. H. Gibson. (Roy. Soc. Edinburgh, Trans. 48. 20. pp. 391-416, 1912.)—The investigation enables a bow-girder to be designed as economically for distribution of material as the straight encasté beam. Quantitative data are calculated and plotted.

E. J. S.

352. Euler's Breaking Formula for Compound Bars. A. Lechner. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1189-1196, July, 1912.)—A mathematical discussion of the formula for a simple and a compound bar.

E. H. B.

353. Relativity Theory. J. Petzoldt. (Deutsch. Phys. Gesell., Verh. 14. 28. pp. 1055-1064, Dec. 15, 1912.)—A quasi-philosophical discussion of relativity theory and its connection with other views of natural phenomena.

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E. H. B.

354. *Relativity and Gravitation.* G. Nordström. (Phys. Zeitschr. 18. pp. 1126-1129, Nov. 15, 1912.)—A highly analytical treatment with reference to Einstein's hypothesis which makes the speed of light depend on the gravitation potential. [See Abstracts Nos. 785 and 1175 (1912).] E. H. B.

355. *Relativity and Mechanical Views of Radiation.* M. La Rosa. (Phys. Zeitschr. 18. pp. 1129-1131, Nov. 15, 1912.)—Discusses the possibility of an experiment which would decide between the relativity principle and the dynamical or electromagnetic views of radiation of light. E. H. B.

356. *Correlation between Atmospheric Pressure and Rainfall in the East-Indian Archipelago in connection with the 8.5 Yearly Barometric Period.* C. Braak. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 454-461, Nov. 28, 1912.)—Although the changes in the weather from day to day in the East Indies are very small there are large variations in the character of the seasons in different years. The author in the present paper puts forward the method of correlation as a possible help in forecasting the seasonal weather. Changes in pressure are considered to be hopeful for forecasting, while an important element from a practical point of view is the rainfall. Since a connection between the variations of pressure and rainfall may naturally be looked for, correlation coefficients have been calculated between the pressure at Port Darwin [see Abstract No. 789 (1912)] and the rainfall for certain groups of stations the observations from which are published by the Batavia Observatory. Monthly values are dealt with, the period used being 1888-1908. The coefficients for each month of the year and for each group of stations are set out in a table. Few of the coefficients exceed 0.5. The paper concludes with a discussion of the possibility of forecasting the pressure-changes. J. S. D.

357. *On the Origin of Solid Precipitation.* G. Hellmann. (Preuss. Akad. Wiss. Berlin, Ber. 46. pp. 1048-1050, 1912.)—Meteorological literature recognises two different kinds of solid precipitation, viz. ice stones and glazed frost. The former are frozen raindrops, hard as glass and transparent, and about 8 to 4 mm. in diam. They are not to be confused with hailstones nor with soft hail. Glazed frost is produced when supercooled raindrops strike any object. It forms a glassy ice surface which covers all objects exposed to the rain. On the morning of November 8, 1912, a form of solid precipitation occurred in Berlin which was different from either of the above. A snow shower was succeeded by the shower of solid precipitation, which lasted half an hour and was in turn replaced by a fine drizzling rain. The small pieces of ice, of which the precipitation consisted, were very irregular in shape, having many points and corners. They were hard and transparent, and may be described as ice-splints. The author explains the origin of the precipitation by supposing that the snow which was formed in a high and cold layer passed through a lower warm layer, was partially melted there, and finally traversed another cold layer at the surface in which it became frozen again. Observations by means of kites at the observatory at Lindenberg support this view, as a warm and humid layer was found there on that morning at a level of about 1000 m. R. C.

358. *Temperature Observations of Soil covered with Different Materials.* P. Vujević. (Meteorolog. Zeitschr. 29. pp. 570-576, Dec., 1912.)—At the Belgrade Meteorological Observatory, besides the other regular observations, the temperatures of the ground covered with small layers of

sand, limestone, moist soil, and grass were recorded. For these observations mercurial thermometers with cylindrical bulbs were employed in preference to the spherical form, since a greater part of the mercury contents coming into close contact with the soil, the true temperature of the latter is more accurately and quickly obtained. The instruments were shielded from the sun, and read hourly throughout the day and night. The material used by the author has been to a large extent hitherto unpublished for the years 1904 to 1906, and has been worked up by him; he has derived mean values for annual and diurnal range for each of the different surfaces. He considers his results more reliable for the summer months, since in winter the grass is withered and the snow can scarcely be completely removed from the turf soil. In the discussions, the temperature-differences of the other materials are constantly compared with regard to the sand-covered surface. It appears that the latter has always a higher temperature than the others, and the difference is much greater in summer than in winter, progressing regularly from Jan. to July and then falling off, its value being 20 times as much in summer (1.54°) as in winter (0.08°). In summer, on account of its low specific heat and the strong sunlight, the sand becomes much warmer than the other surfaces, whereas the feeble sunlight of winter produces but a slight effect. Tables are given of the deviation of the monthly means from the annual mean temperature of the three different surfaces; of the hourly variations from the mean of the month for April, July, and Oct.; of the night temperature for the summer months May and July; corrections for the elimination of the annual effort from the daily range of temperature for each month; and finally the daily range of temperatures at every hour of the 24 for each month for the three surfaces. The effect of evaporation in lowering the temperature between the hours of 11 a.m. and 6 p.m. is very evident, and the author has already dealt to some extent with this in a former paper. [See Abstract No. 442 (1912).]

F. W. H.

359. On Atmospheric Cooling and its Measurement: an Experimental Investigation. J. R. Milne. (Scottish Meteorolog. Soc., Journ. 16. No. 29. pp. 9-17, 1912.)—The experiments discussed were made with a view to obtaining a satisfactory expression for the rate of loss of heat from a body maintained at a certain temperature and freely exposed to atmospheric influences. An instrument was devised to give a continuous record of this rate of loss of heat, and the records obtained are compared with simultaneous records of wind velocity and temperature (the latter being from a freely exposed bimetallic thermograph). A provisional formula is put forward connecting the rate of cooling with the wind velocity and temperature. Fairly satisfactory agreement is found between the values given by this formula and the actual values measured. The author hopes to continue the work, and when more data have been accumulated to establish a reliable formula for meteorological cooling.

J. S. Di.

360. Comparison Measures with Pyrheliometers. W. Marten. (Phys. Zeitschr. 18. pp. 1212-1216, Dec. 15, 1912.)—In furtherance of the scheme proposed at the Innsbruck Conference of the International Meteorological Committee, and at the Oxford Meeting of the Solar Union, 1905, comparisons have been made between the solar constant given by Ångström's pyrheliometer and other standard instruments.

C. P. B.

361. Tidal Phenomena in the Western Mediterranean. R. v. Sterneck. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1245-1288, July, 1912.)—This work is in

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extension of the researches by the author's father and himself on tidal phenomena in the Adriatic during the period 1904-7 [see Abstract No. 1578 (1908)], and after journeys in the spring of the years 1909, 1911, and 1912 to the coasts of the Western Mediterranean it became possible by means of his own observations and the data supplied by mareograms to prepare the present paper. The limited number of satisfactory observations available and the small range in variation of the water-level produced by the tides (often not more than 20 cm. and sometimes even less), the want of knowledge of the "establishment" times over wide areas, and the lack of self-registering instruments have all hitherto been difficulties in the way of forming a satisfactory theory of tidal phenomena in this sea. Grablovitz, however, in 1909 collected and arranged the hitherto available material in a most useful manner, and records of the mareograms at the Italian stations where the self-recording instruments were in use have been published by the Italian "Istituto Geografico Militare," whilst the author's own observations and determinations helped to fill up many of the principal gaps, and have thus enabled us to form a fairly complete representation of the course of tidal phenomena through the Western Mediterranean. After some preliminary remarks as to the method employed by him for the reduction of observations, the duration of time between the moon's upper and lower transits over the meridian and those of high and low water, together with explanation of the symbols employed, the author gives time and height of high water at syzygy for 50 Mediterranean stations. The existence of nodal lines, one between Corsica and the Balearic Isles, the other in the Tyrrhenian Sea, is confirmed and indicated in a chart accompanying the paper. From the formula $(2\pi/T)^2 = 8gh/a^2$, by insertion of determined values for the Tyrrhenian Sea he obtains the period $T = 0.657$ hour, and 0.670 for the sea north-west of Sardinia, 0.648 hour for the part to the south, these very short periods of oscillation having evidently no relation to the fundamental period of the tide itself (12.4 hours). The diurnal inequality is small and almost evanescent at the time of the equinoxes, but at other times of the year at full and new moon it has appreciable values. Almost all the mareographic records give evidence of the existence of the small secondary oscillations known as seiches, one whose period is 27.0 mins. and amplitude 2.5-10 cm. occurring at Barcelona, whilst at Palma a period of 18.6 mins. and amplitude 8-12 cm. exists, and at Mahon two alternating periods of 15.7 and 35.8 mins. with amplitudes of 1.5 cm. to 11 cm. occur, etc., the longest period of all observed being for Goletta in Tunis, where an oscillation having a periodic time of 45.0 mins. but with amplitude only 6-8 cm. was found. Tables of the results of the observations at Goletta, Nice, Marseilles, Cette, Valencia, and Alicante from the mareograms and at Barcelona, Palma, Port Mahon, and Oran from eye observations are given at some length, and finally a summary of results. The idea that there is a periodic ebb and flow through the strait between Sicily and Tunis is rejected as improbable. Besides the two regions with hypothetical closed nodal lines already referred to, there is a third which reaches from the Balearic Isles to Gibraltar and has a single east-west oscillation. In these three regions there can only exist forced oscillations under the influence of Sun and Moon, since, as calculation shows, the fundamental period is much shorter than 12 hours, and the general small amplitude of these is also an evidence of this, since it does not exceed 20-30 cm.

F. W. H.

362. *Temperature Observations in Loch Earn.* E. M. Wedderburn. (Roy. Soc. Edinburgh, Trans. 48. 26. pp. 629-695, 1912.)—This paper deals with VOL. XVI.—A.—1918.

observations undertaken with the view of determining the cause of the temperature seiche and the effect of varying meteorological conditions. For this a knowledge of the changes occurring at all points is necessary, and observations at frequent intervals at numerous depths and from several distinct regions of the lake are required. Loch Earn was chosen for the same reasons as weighed with Chrystal in his seiche investigations : the uniformity of the basin, its convenient size, and its accessibility, and also because the ordinary seiches had been so carefully investigated by him that it was hoped the loch would be found as well tuned for the temperature seiche. All the observations were made during Aug., 1911 ; five stations along the loch at distances of about $1\frac{1}{4}$ miles from one another were selected, and 22 observers, including the author, were employed. It being found impossible to have regular hourly observations at each station, each observation consisting of the determination of temperature at eight or nine different depths, 2-hour observations were in general substituted, but as a rule regular hourly observations were kept during daylight at three of the stations. Observations were also made of the direction and velocity of the current at different depths by means of two Ekman current-meters, and the results are given in a table, but the author has not found it possible to draw any clear conclusions from them. The temperature observations at various depths from 0 to 60 m. below the surface at the five stations are recorded at full length, and diagrams illustrating some of the results are also given. These diagrams show that in the earlier part of the month there was a well-marked oscillation of the isotherms, and that the phases of the oscillations at stations I and II were the same, and directly opposite to those at IV and V. At station III (middle of lake) they are different in character and much shorter in period. Thus it is clear that the seiche theory of the oscillations is the true one, the long-period oscillations being absent at III on account of the proximity of the "uninode." Thus temperature seiches do exist, and are of the nature of a standing boundary wave. Winds of even very moderate strength will start oscillations, and examples of oscillations forced by wind have been obtained. The author gives a discussion of the hydrodynamical theory of temperature oscillations, and he finds the whole theory to depend on the differential equation $\partial^2 P / \partial v^2 + n^2 P / g\sigma(v) = 0$, where $u = \Sigma P \sin n(l - \tau)$, P is a function of v alone, and T is constant. The methods used by Chrystal are thus available here. Calculations of the period for Loch Earn by approximate methods are next made, and the results given by means of a table and diagram. With certain assumptions a period of 14.99 hours was obtained, agreeing closely with the observed period of 15.2 hours (for 1 p.m. on Aug. 8), whilst for Aug. 15 the observed and calculated periods were found to be 14 and 13.8 hours respectively, the binodal period under the same conditions being 8.44 hours calculated and 8.2 hours observed, the ratio of the two observed values $15.2/8.2 = 1.79$ being thus greater than for the ordinary seiche, though theoretically it should be nearly the same ; and the author attributes the discrepancy to the less accurate nature of the assumptions on which the theory rests for the "higher nodalities." [See also Abstract No. 587 (1911).]

F. W. H.

363. Attraction of Sun-spots for Prominences. F. Slocum. (Astrophys. Journ. 36. pp. 265-268, Nov., 1912.)—Examination of a series of spectroheliograms taken during the life of the large group of sun-spots visible during Aug., Sept., and Oct., 1910, showed evidences of very considerable activity both in the spot form and the neighbouring prominences when the spot was near the limb. Bright eruptions were constantly appear-

ing and disappearing, and on several occasions dark flocculi were observed in the vicinity. Photographs taken on Oct. 8 are reproduced to illustrate several of the more interesting changes. The most striking feature is that the prominences are seen to be pouring from both sides apparently down into the large spot. Measurements on recognisable features of the prominence matter gave velocities along the trajectory of 16, 20, and 60 km. per sec., at distances of 170,000, 180,000, and 75,000 km. from the centre of attraction. In some few cases there also appear to be evidences of repulsion. Hale and Evershed have previously given instances of gaseous matters exhibiting tendencies to move towards the sun-spot vortices, but their results indicated diminishing velocities as this centre was approached, whereas these by Slocum indicate acceleration towards the centre.

C. P. B.

364. Motion of Solar System. W. H. Pickering. (Roy. Astronom. Soc., M.N. 72. pp. 740-748, 1912.)—Several facts point to the probability of the existence of an interstellar absorbing medium. The present note deals with the motion of the solar system relatively to such a medium, which may be simply the ether or that with some gaseous product. Attention is devoted specially to the comets, moving as they do throughout vast regions from the immediate neighbourhood of the sun to the farthest boundaries of the solar system. If there be an absorbing and resisting medium, then as the mass of a comet is much less in proportion to its surface than that of the sun, the aphelia of all comets of long period would tend to fall behind the sun in its path, and should be concentrated towards the anti-apex. A diagram is given showing the longitudes and latitudes of the aphelia of all the parabolic orbits, and it is evident that the aphelia of the brighter comets show a definite concentration in certain regions, notably near the position $\lambda = 97^{\circ}2$; $\phi = -16^{\circ}8$ (sun's anti-apex is $\lambda = 90^{\circ}5$; $\phi = -34^{\circ}8$). The difference might be caused by (a) the absorbing medium not being stationary with regard to the stars as a whole, or (b) by the sun moving in a curve instead of a straight line. Confirmation of or distinction between these possibilities requires further observations, but there appears to be evidence that the solar motion relatively to the resisting medium differs somewhat in direction, but not very greatly, from its motion relatively to the stars.

C. P. B.

365. Constitution of Solar Corona. J. W. Nicholson. (Roy. Astronom. Soc., M.N. 72. pp. 729-789, 1912.)—Further examination of the corona spectrum on the theory developed by Planck and others [Abstracts Nos. 841, 1648 (1912)] leads the author to find theoretical constitutions of atomic arrangements accounting for many of the lines. A complete analysis of the investigation is given, with a table showing the electronic compositions for each line recognised; also a list of 18 lines which are still unexplained, the most important of these being $\lambda 5808$, $\lambda 4568$, and $\lambda 4859$. An interesting fact is noted, namely, that the cube roots of the wave-lengths of three of the most important lines, 5808, 4859, 8584, have constant differences, so that they probably have a like origin.

C. P. B.

366. Variations of Solar Spectrum Wave-lengths. A. Perot. (Journ. de Physique, 2. Ser. 6. pp. 975-986, Dec., 1912. Paper read before the Soc. franç. de Physique, June 7, 1912.)—From the results of an investigation of the rotation period of the sun by means of radial velocities from spectrographic observations at the limb, various workers have formulated an empirical law of rotation with the solar latitude as one argument. By

considering the velocity in km. instead, of angular movement, the author finds it possible to express the velocity of rotation at any latitude as a function of the latitude, together with a small reduction constant; this strongly suggests the idea that the rotation velocity observed is the resultant of the rotation of a solid body and a constant retardation component independent of the latitude. He next describes a powerful spectograph with interferometer attachment for a rigid determination of the rotation period, and of the peculiar augmentations of wave-length shown by spectrum lines at the solar limb, which have been ascribed to the effect of pressure in the reversing layer. This augmentation of the wave-length exists all round the disc, and is apparently independent of the solar rotation; it has also been supposed to be due to anomalous dispersion of the light passing through the denser layers of the solar atmosphere. A possible explanation is suggested involving the action of the descent of electrons into a layer of rotating gas. The movements at the surfaces of interaction might conceivably be of the nature suggested by the rotational vortices discovered by Hale, and proved to be regions with magnetic fields. The helical motions of many prominences mentioned by Deslandres also suggest the interaction of electrons with a magnetic field.

C. P. B.

367. Magnetic Field in Solar Atmosphere. H. Deslandres. (*Comptes Rendus*, 155. pp. 1578-1581, Dec. 30, 1912.)—The author gives a long discussion of the evidence for the existence of a magnetic field in the higher solar atmosphere. Certain prominences have been observed to have a distinct helicoidal structure, very similar to what would be expected in the case of an ion projected into a magnetic field, and a phenomenon easily reproduced experimentally. Drawings are given showing the probable deviation of the prominence matter in the direction of the sun's rotation, and the resulting differentiation of the absorption phenomena at the east and west limbs.

C. P. B.

368. Origin of Planets and Satellites. K. Birkeland. (*Comptes Rendus*, 155. pp. 892-895, Nov. 4, 1912.)—Based on his experimental researches on the forms assumed by various types of kathode discharge, the author suggests that many of the phenomena of the solar system may be due to the action of electromagnetic forces of the same order of magnitude as gravitation. It is probable that the particles of matter driven off, from the sun say, carry with them a positive charge, and the research follows to some extent the idea of determining the paths of such particles when subjected to the action of magnetic or electrostatic fields. There thus would be produced in the equatorial magnetic plane of the sun a series of limiting circles, about which the emitted particles would accumulate. Mention is also made of the possible production of heat by cathodic disintegration, and the similarity to the process of evolution of β - and α -rays from radio-active bodies.

C. Störmer. (*Ibid.* pp. 1078-1075, Nov. 25, 1912.)—Störmer refers to his own suggestion of the same explanation in 1907 [Abstract No. 1927 (1911)], and gives some formulæ in comparison with the results indicated by Birkeland for the trajectories of the charged particles.

K. Birkeland. (*Ibid.* pp. 1467-1470, Dec. 28, 1912.)—In continuation the author considers the result of the emission by the sun of the charged particles to be that the body becomes negatively charged. A photograph is reproduced showing the type of discharge produced from a kathode 24 cm. diam., feebly magnetised, with a continuous discharge of 100 milliamps. Another figure shows

the effect of disruptive charges, with rotational movements in opposite directions in the two hemispheres, very similar to the vortices found by Hale in sun-spot areas.

C. P. B.

369. *Transit of Mercury, November 14, 1907.* N. Donitch. (Acad. Sci. St. Pétersbourg, Bull. 17. pp. 1011-1080, Dec. 1, 1912.)—On account of the difficulty experienced in obtaining records of the spectrum of Mercury under ordinary conditions, advantage was taken of its passage across the sun's disc on Nov. 14, 1907, to secure a series of photographic spectograms, special attention being devoted to the two positions of internal contact. The observations were made at Assouan, in Upper Egypt. After a short *résumé* of the history of the phenomenon, first observed by Gassendi in 1681 at Paris, a description of the apparatus employed on the author's work is given. This consisted of a Zeiss objective, 10 m. focal length, giving an image of the sun about 9.5 cm. diam., and an image of Mercury about 0.5 mm. diam. at the primary focal plane. During the exposures the objective was diaphragmed down to 5 cm. The diurnal motion was compensated by an electrically-controlled Lippmann cœlostast, with a secondary mirror to keep the reflected beam in the meridian. In order to obtain a magnified image on the slit an enlarging lens of 285 mm. focal length was employed. The spectroscope had a single Zeiss prism of 60° angle, with camera lens of 273 mm. focal length. A long discussion is given of the means adopted for determining the changes of intensity of the spectrum lines over the image of the planet, with the conclusion that it is doubtful if an atmosphere extends as high as 15 km. from the planet's surface.

C. P. B.

370. *Satellite Systems of Planets.* E. Belot. (Comptes Rendus, 155. pp. 1471-1478, Dec. 23, 1912.)—The general hypothesis is formulated that the satellite system of planets consists not only of the detached satellites, but also includes the masses condensed along the equatorial regions, and only prevented from becoming separated by the resistance of the medium and the attraction to the centre. This view appears to be verified by the known fact that the equatorial zones of the bodies of great mass (Sun, Jupiter, Saturn) rotate more rapidly than the other regions; also by the relatively low density of the surface materials of the planets compared with the density of the isolated satellites.

C. P. B.

371. *Spectrum of Comet Gale (1912a).* P. Idrac. (Comptes Rendus, 155. p. 896, Nov. 4, 1912.)—Photographic observations of the spectrum of Comet Gale (1912a) were obtained at the Meudon Observatory with a prismatic camera [Abstract No. 1086 (1910)] attached to the 8-in. equatorial. The plates show the characteristic cometary spectrum consisting of the radiations of hydrocarbon and cyanogen.

C. P. B.

372. *Photographs of Nebulae and Star Clusters.* H. D. Curtis. (Lick Observatory, Bull. No. 219. Nature, 90. p. 841, Nov. 21, 1912. Abstract.)—The paper gives a detailed description of 182 objects photographed with the Crossley Reflector at Lick Observatory. Attention is drawn to the additional information given by the photographic records.

C. P. B.

373. *Darkening at the Limb in Eclipsing Variables.* H. N. Russell and H. Shapley. (Astrophys. Journ. 86. pp. 239-254, Oct., 1912.)—Up to the present time the problem of determining the orbital elements of an eclipsing

binary from the light-curve has been investigated on the assumption that the stars are without appreciable absorbing atmospheres. In this paper the authors continue the method outlined previously [Abstracts Nos. 203 (1911), 1664 (1912)] for introducing the varying brightness from limb to centre into the discussion, and give formulæ and reduction tables for total eclipsing conditions. (Ibid. pp. 885-408, Dec., 1912.) Extends the analysis to the cases of annular and partial eclipses. C. P. B.

374. Study of Scintillation. C. Gallissot. (Comptes Rendus, 155. pp. 1184-1186, Dec. 2, 1912.)—Scintillation of stars is manifested by rapid changes of brightness accompanied in most cases by changes of colours. This is found to influence the estimation of star magnitudes, and the effect is different for different colours. C. P. B.

375. Influence of Colour and Magnitude in Stellar Photometry. C. Gallissot. (Comptes Rendus, 155. pp. 1590-1592, Dec. 30, 1912.)—In the estimation of the relative brightness of luminous areas Broca and Sulzer found interesting differences introduced when the illumination was variable; the Purkinje phenomenon diminished when the areas were diminished in diam. The effect is of importance in the estimations of stellar photometry owing to the presence of more or less scintillation when working with small instruments or the naked eye [Abstract No. 874 (1910)]. Measurements have been made with white light, and with coloured lights obtained by selecting regions of the spectrum by coloured screens. In the case of short illuminations separated by intervals of 1 sec., the brightness was almost always estimated as fainter than when the light was steady. This error of estimation for a given duration of illumination increases when the actual brightness diminishes and more rapidly for blue radiations than for red. [See preceding Abstract.] C. P. B.

376. Yerkes Actinometry. J. A. Parkhurst. (Astrophys. Journ. 86. pp. 160-227, Oct., 1912.)—The main object of the investigation was the co-ordination of the visual and photographic magnitudes of stars, the present paper dealing with the measurement of the stars of the Potsdam Photographic Durchmusterung from $+78^\circ$ to $+90^\circ$ declination. The observations were made on photographs taken with a Zeiss doublet lens of 14.5 cm. aperture, 81.4 cm. focal length, furnished with an objective prism of the same aperture and 15° angle. The method of extra-focal image diameters was used for the determination of photographic magnitudes. These values were corrected for the colour-curve of the lens. For the magnitudes on the visual scale, focal-plane images were taken on colour-sensitive plates with a specially designed and corrected filter. The differences between photographic and visual magnitude are classified with the type of spectrum as given by the Harvard system. C. P. B.

377. Spectrum of β Scorpionis. J. C. Duncan. (Lowell Observatory, Bull. No. 54. Nature, 90. p. 894, Dec. 5, 1912. Abstract.)—From a series of new measurements of the radial velocity of this interesting spectroscopic binary it is found that the values given by the calcium (K) line are distinctly abnormal compared with the velocity given by other spectrum lines. A similar phenomenon has been noted by Hartmann in the case of δ Orionis, and it has been suggested to be due to the presence of cosmically-distributed calcium vapour between the earth and these stars. C. P. B.

378. *Spectrum of Nova Geminorum* (1912). W. S. Adams and A. Kohlschutter. (Astrophys. Journ. 86. pp. 298-321, Nov., 1912.)—The first observations of the spectrum of Nova Geminorum (1912) were made on March 22, nine days after its discovery by Enebo. All the photographs were obtained at the 80-ft. focus of the 60-in. reflector and Cassegrain spectrograph at the Mount Wilson Observatory, California. At first a single prism of 68° angle with a camera lens of 102 cm. focal length was used; after April 5 this lens was replaced by one of 46 cm. focal length. Fourteen photographs of the spectrum of the Nova were obtained from March 22 to May 27, 1912. During the early stages of the life of the star the spectrum consisted of numerous broad bright bands, with strong continuous spectrum and many dark lines, the most prominent of these latter being situated on the more refrangible edges of the hydrogen lines. Each of the hydrogen bands showed multiple structure similar to that observed in previous Novæ spectra. The rapid changes in the spectrum from night to night are well shown in a series of spectra extending from March 22 to Aug. 19, reproduced with the paper. Towards the later stages the lines characteristic of nebulae became conspicuous, the lines of helium, etc., which had been very strong during the intermediate stages, becoming evanescent.

Special attention was devoted to the determination of the radial velocity of the system, the measurements being made on the narrow absorption lines of calcium (H and K), some faint lines of iron, and the narrow sodium lines D₁D₂. The adopted velocity is given as +10 km. per sec. Attention is drawn to the latest phase of the spectrum, which in some respects resembles that of the Wolf Rayet star spectrum, and one of these spectra is shown for comparison. A long list of wave-lengths is given for the lines measured in the spectrum from $\lambda 8868$ to $\lambda 6677$, with the probable origins of as many as could be identified. As the component lines varied greatly from time to time, any detailed reference to these can only be of value in comparison with the photographs of the spectra. With the idea of detecting any possible polarisation in the spectrum lines, two spectrograms were obtained on April 7, using a Nicol prism and a quarter-wave plate in front of the slit; no displacements of the bright maxima were discernible on rotation of the quarter wave-plate. C. P. B.

379. *Constants for Two Star-streams*. J. C. Kapteyn and H. A. Weersma. (Roy. Astronom. Soc., M.N. 72. pp. 748-756, 1912.)—Details are given of the formulæ used in the determination of the elements of the two great star-streams outlined in lectures given by Kapteyn at St. Louis in 1904, and in South Africa in 1906. Very much simplified solutions have been published by Eddington, Dyson, and Schwarzschild, but they base their derivations of the stream elements exclusively on the number of proper motions in different position angles, whereas in the method of Kapteyn the amount of the proper motion is considered in addition. C. P. B.

380. *Elements of the Eclipsing Variables W Delphini, S. Cancri, SW Cygni, and U Cephei*. H. Shapley. (Astrophys. Journ. 86. pp. 269-285, Nov., 1912.)

381. *Identification of Small Planets*. L. Fabry. (Comptes Rendus, 155. pp. 946-948, Nov. 11, 1912.)—A short analysis is given of a method of quickly examining the reduced positions of any minor planet observed, so that it may be at once ascertained whether it is one already known, or is a new discovery.

C. P. B.

LIGHT.

382. *New Bar Photometer for Measuring Densities by Non-parallel Rays.* **W. B. Ferguson.** (Photographic Journ. 52. pp. 288-287; Discussion, pp. 287-290, Nov., 1912.)—The researches of A. Callier, F. F. Renwick [Abstracts Nos. 1278 (1910), 1851 (1912)], and others have shown that there is no such thing as one true value for the density of a granular silver photographic deposit, but that the value of the density of a photographic plate depends on the set of circumstances in which it is measured; the very different values obtained for the same deposit, when observed in different photometers, due to the different amounts of scatter in each case, have led to the conclusion that the most useful method of density measurement is one in which the max. amount of scatter is produced by making the measurements with the film in contact with opal glass, or some similar diffusing medium which is placed between the film and the source of light. The value of the optical density to non-parallel rays (D_K) so obtained is applicable to contact printing, and differs but little from the true photographic density (D_ϕ) obtained by Renwick's method. The special points in the new photometer are: Its readings depend merely on the law of inverse squares and such measurements as can be taken off a metre rule. It is not a comparator, and its accuracy does not depend on the previous calibration of a wedge. The results obtained are free from any varying error due to scatter such as occurred in the Hurter and Driffield instrument. There is no variation in the comparative intensity of the two lights used, both being run in parallel off the same electric circuit. There is no screen between the plate and the observer. The matching of two illuminated patches always takes place at the same intensity, and is thus rendered easier to the eye, while by the simple device of a compensation screen the two patches are rendered of the same tint. There is no uncertainty due to the use of polarised light: an objection which has been raised against the Hufner and Marten forms of photometer. It will measure the smallest densities with an accuracy which depends solely on the eye of the observer. Any part of the plate can be measured. By the substitution of an Abney screen and the removal of a diffusing plate, it may be used for measuring densities in parallel light ($D_{||}$). It is simple in design, inexpensive to construct, and is easily put in adjustment for use. In the *discussion*, **Chapman Jones** pointed out that the arrangement was practically the Abney screen as modified by the use of opal glass, but with the positions of the plate to be measured and the opal reversed. The author said the abolition of the translucent part of the Abney screen got rid of the objection which had been raised, that in the case of that screen what was measured was the opacity of a piece of paper modified by placing a negative in front of it, and the results were rendered erroneous by mutual reflection between the negative and the paper *after* the light had passed through the negative. Any reflection which takes place in the new instrument happens *before* the light passes through the negative, and would not affect the result. A. E. G.

383. *Grating Spectrograph.* **L. Geiger.** (Ann. d. Physik, 89. 4. pp. 752-788, Nov. 12, 1912.)—Describes a grating spectrograph in which no glass is used, and its use for photographing lines in the ultra-red iron spectrum. Light from a slit falls on a small plane mirror (M_1) and is thence reflected at
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right angles on to a second mirror (M_2), which has a silvered spherical surface of about 85 cm. radius of curvature, the diam. of the mirror being 9.6 cm. This mirror renders the light parallel, and the light is then allowed to fall on the plane reflecting grating 5 cm. \times 8 cm., with 14,438 lines to the inch. The angle of incidence of the central ray of the diverging beam falling on M_2 is about 10° . The grating is mounted on a graduated circle. The light from the grating after reflection from M_2 converges to give a spectral image on the photographic plate. A slight adjustment of the mirrors allows the light reflected from M_2 to miss the small mirror M_1 . The arrangement is shown to be stigmatic and gives strong illumination. A full discussion of details is given; 216 lines of the iron spectrum, from $\lambda 6750$ to $\lambda 9809$, were photographed; the error in the wave-lengths is calculated to be not more than $1/100 \text{ \AA}$. A. W.

384. *Refractometers*. **T. M. Lowry**. (Phys. Soc., Proc. 24. pp. 400-404, Oct., 1912).—A paper discussing some points in the use and design of refractometers. The ordinary standard wave-lengths (Na D-line, C, F, and G lines of hydrogen) have several disadvantages. It is suggested that a much better series would be Li 6708, Na 5898, Hg 5461, Hg 4859, as used previously by Dorn and Lohmann in their measurements of the refractive indices of liquid crystals. The author has found that, in the case of a large number of simple organic compounds, the optical and magnetic rotatory dispersions may be expressed by simple formulæ of the type $a = a_0/(\lambda^2 - \lambda_0^2)$. In this equation the absolute optical or magnetic rotatory power of the substance is expressed by a single constant a_0 , whilst the rotatory dispersive power is expressed by a second constant λ_0 . Thus, in this case, the actual wave-lengths employed in determining the constants are of little importance, as any suitable pair should give the same result. Refractive dispersion is more complex, but measurements appear to be of little use until we possess more knowledge of the dispersion law for typical organic compounds in the infra-red, visible, and ultra-violet regions of the spectrum. Gifford's experiments have shown marked variations of refractive index in prisms of the same glass, even when taken from the same melting. Hence refractometers need to have their tabulated data checked. The most convenient method is by means of a piece of quartz, cut so as to give both the ordinary and extraordinary ray; fluorite, calcite, and silica may also be used. The following table gives the refractive indices, determined by Gifford, for these substances for various Li, Cd, and Hg lines:—

λ .	Fluorite.	Quartz. (Ordinary Ray.)	Quartz. (Extraordinary Ray.)	Calcite. (Ordinary Ray.)	Calcite. (Extraordinary Ray.)	Vitreous Silica.
6708 Li	1.48226	1.54146	1.55047	1.65367	1.48427	1.45607
6488 Cd	—272	—281	—185	—508	—468	—877
5461 Hg	—499	—617	—584	—165	—789	1.46015
5086 Cd	—619	—824	—748	—527	—954	—190
4900 Cd	—691	1.55018	—945	—861	1.49110	—857
4859 Hg	—952	—880	1.56828	1.67518	—410	—674
4046 Hg	1.44158	—715	—671	1.68184	—691	—968

From these data it is possible to deduce the refractive power of a liquid from the angular readings of the refractometer for the new series of wave-lengths.

The trouble of calculating may be avoided by using the correction curves reproduced in the paper, and which were worked out by F. Tinker. The water-jacketing usually supplied with the Pulfrich refractometer appears to be very inefficient, and gives rise to such large possible temperature-differences that all measurements made with this instrument in the higher ranges of temperature can scarcely be trusted. A refractometer prism, with water-jacket designed to overcome the defects of the Pulfrich instrument, has been constructed, but no tests have as yet been made with it. A. W.

385. Self-testing of Dispersion Apparatus. C. V. Burton. (*Nature*, 90. pp. 435-436, Dec. 19, 1912.)—In testing a plane grating, echelon, or other dispersive apparatus by the usual method of crossing its dispersion with that of an auxiliary piece, unless the resolving power of the auxiliary dispersion is in some degree comparable with that of the piece to be tested, it is scarcely possible to identify ghosts which lies close to their primaries. The author suggests that the difficulty may be removed by using an arrangement of two front-reflecting mirrors to cross the echelon, say, with its own dispersion. One of the mirror faces has one truly straight edge, at which the dihedral angle, in contact with the face of the second mirror, is 90° or less. The two mirrors are set exactly at right angles to one another, and placed so that their line of contact is inclined 45° to the horizontal, while the vertical plane through the line of contact bisects externally the angle between the mirrors. The light would thus pass successively through a slit (shortened to a minute square), an objective, the echelon, and after reflection at the mirrors would return through the echelon and objective and be brought to a focus in the plane of the slit. An accurately right-angled prism with reflecting faces meeting in a sharp line could be substituted for the pair of mirrors. The suggested arrangement could be modified by allowing the beam to pass through a second lens and be brought to a focus, being then reflected by a small right-angled prism through the whole system; but this necessitates four transmissions through objectives. A similar arrangement may be employed for echelon gratings of reflecting type. A. W.

386. Imitation of Double Refraction by Glass Plates. E. Terlanday. (*Ann. d. Physik*, 89. 6. pp. 1207-1229, Dec. 28, 1912.)—Doubly-refracting crystals are imitated by a pile of glass plates placed obliquely, various angles being tried. In some cases two polarised beams are obtained as well as one unpolarised, three in all. The possible constitution of crystals is discussed at some length, reference being made to certain models of constituent parts grouped in different fashions. It is concluded that in such models, the form of the intervals, the density of the material in these intervals, and the dimensions all have an effect on the result. E. H. B.

387. Indices of Doubly-refracting Crystals by Displacement Interferometry. C. Barus. (*Phil. Mag.* 24. pp. 827-887, Dec., 1912. Abstract of Report to Carnegie Inst. of Washington.)—Describes the arrangements used and examines the order of accuracy obtainable. The interferometer was an improvised apparatus made of $\frac{1}{4}$ -in. gas pipe through which water continually circulated. It is claimed that $\mu-1$ was measurable with an accuracy of one part in a million. [See Abstract No. 1881 (1912).] E. H. B.

388. Double Refraction of Unannealed Glass. H. Schulz. (*Phys. Zeitschr.* 18. pp. 1017-1028; Discussion, pp. 1028-1029, Nov. 1, 1912. VOL. XVI.—A.—1918.

Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—A method is described whereby the strain (due to cooling) in glass plates may be investigated and measured. Light from a mercury lamp passes first through a monochromator, and light of known wave-length thus falls on a slit, then in succession passes through a convex lens, a polarising nicol, a Soleil-Babinet compensator, a diaphragm which reduces the width of the beam, and the glass slab under investigation. The rays then fall on a combination of two right-angled prisms placed with the reflecting faces close together, but separated by a thin film of air, which arrangement gives rise to a set of interference fringes. From the double prism the light passes through an analyser and is viewed through a telescope. Specimens could be dealt with up to 80 cm. diam. The interference fringes were utilised in determining the amount of strain along the path of the light. Some slabs showed a minimum strain near the centre, but the strain increased rapidly along lines from the centre to the edge. Other slabs, which had been slowly cooled, showed a zone of considerable area practically free from strain, but beyond this the strain increased sharply to the edge. For diagrams and photograph of the apparatus, with method of use, see original paper. A table is given showing the effect of various cooling processes on the amount of strain produced. In the *discussion*, in reply to Ebert, the Author said the apparatus might be used to investigate the effect of strain produced mechanically. A. W.

389. *Interference Phenomena in Glass Wedges.* E. von der Pahlen. (Ann. d. Physik, 89. 6. pp. 1567-1589, Dec. 28, 1912.)—When a pencil of parallel or nearly parallel rays falls at an angle of incidence ϕ on to a feebly wedge-shaped plate of glass of angle ϵ and mean thickness D , with the plane of incidence normal to the thin edge, then interference fringes are produced, both by reflected and by transmitted light, at a distance E from the centre of the surface, where $E = D \sin \phi \cos^2 \phi / (\epsilon n^2 - \epsilon \sin^2 \phi)$. These fringes are parallel to the thin edge, and lie in a plane containing the thin edge and forming with the surface of the plate an angle α given by the relation $\tan \alpha = \sin \phi \cos^2 \phi / (n^2 - 1 + \cos^4 \phi)$. When the incident light is directed towards the thin edge, this plane is, in the case of reflected light, on the same side as the source, and the fringes are real, both in reflected and in transmitted light. When the light passes in the reverse direction as regards the edge, both planes lie on the side of the plate opposite the interfering rays, and the fringes are vertical. Their apparent distances apart, projected on a plane normal to the line of vision, are $= \lambda \cos \phi / 2\epsilon (n^2 - \sin^2 \phi)^{1/2}$. There are other fringes at distances from the above $= \lambda \sin \phi / 2\epsilon^2 \sin \phi \cos (\phi - \alpha)$, where ϕ has the successive values $\pm 0, \frac{1}{2}, 1, 1\frac{1}{2}, 2$, etc. The planes and mutual distances are the same as before. E. E. F.

390. *Scattering of Light.* F. Herzheimer. (Phys. Zeitschr. 18. pp. 1106-1112, Nov. 15, 1912.)—This paper deals with a method of measuring the intensity of the light scattered in various directions around the primary beam. The method has been tested with sal-ammoniac clouds. The absorption is found to reach a maximum about 15 minutes after the formation of the cloud, when a certain size of particles is reached apparently. J. M.

391. *Light Propagation in Layered Media.* A. Garbasso. (Ann. d. Physik. 89. 6. pp. 1078-1107, Dec. 28, 1912.)—The first part of this paper is VOL. XVI.—A.—1918.

theoretical of a general kind, and treats the subject by aid of Lagrange's generalised co-ordinates. The second part deals with the natural phenomena of mirage in its various forms, especially the Vince mirage (one inverted image between two erect ones) and those observed by Monge and by Parnell (two inverted images between three erect ones). Experimental work has also been carried out with gelatines through which are diffused electrolytes.

E. H. B.

392. *Emission from Tungsten and Carbon at Glowing Temperatures.*

A. G. Worthing. (Astrophys. Journ. 86. pp. 845-860, Dec., 1912).—A paper describing experiments which show how the emission from tungsten and carbon deviates from Lambert's cosine law at glowing temperatures. The brightness variation as a function of the angle of emission was measured for carbon at one temperature and for tungsten at two, using light of wave-length 0.68μ ; also for tungsten and carbon at one temperature each, using light of wave-length 0.46μ . It was found that the brightness of tungsten, beginning with normal emission, increases with the angle of emission, reaches a maximum at about 75° , and for somewhat larger angles decreases rapidly. The brightness of carbon, beginning with normal emission, decreases with increasing angle of emission, the rate of decrease increasing with the angle. The relative brightness variations for light of short wave-length 0.46μ for tungsten are noticeably less than those for the light of longer wave-length 0.68μ . The same effect was found with carbon, but the difference is not so great. The relative brightness variations for tungsten at the higher of the two temperatures chosen are about 20 or 25 % greater than the corresponding variations for the lower temperature. No definite change with temperature was found for carbon. The average brightness of a tungsten cylindrical filament, viewed normally to its axis from a distance, is found to be about 8 % greater than the brightness of the central part, that for a carbon filament about 5 % less.

A. W.

393. *Determination of Spectrum Luminosity Curves by the Method of Critical Frequency.* H. E. Ives. (Phil. Mag. 24. pp. 852-870, Sept., 1912. Electrician, 71. p. 59, Oct. 18, 1912. Abstract.)—This paper is supplementary to a previous one [see Abstract No. 1246 B (1912)] in which the existence of a reversed Purkinje-effect with the flicker photometer was noted at low illuminations. The effect is now investigated by the "critical frequency" method, *i.e.* observing the speed at which the flicker-effect of a rotating disc just vanishes. The method leads to a similar conclusion. The reversal takes place about 0.25 candle-metre, where a profound change in the nature of vision seems to occur. The results are affected by the area of the retina on which the luminous image is received; at low illuminations the fovea is most sensitive to flicker with red light, the peripheral retina to flicker with the blue light. These experiments confirm the impression that the cones on the retina are chiefly active in the case of intermittent and alternating stimuli. Rayleigh. (Phil. Mag. 24. pp. 801-802, Aug., 1912).—Rayleigh comments on the recent remarks of H. E. Ives. [see Abstract No. 1246 B (1912)] that no satisfactory theory of the action of the flicker photometer exists. But it is suggested that the sensation of flicker is due to the alteration in the iris of the eye, when exposed to a fluctuating light. Further confirmation of the suggestion might be made by studying experimentally these variations and ascertaining whether the flicker match coincides with quiescence of the iris.

J. S. D.

394. Point Sources of Light. C. C. Paterson and B. P. Dudding. (Phys. Soc., Proc. 24. pp. 879-897; Discussion, pp. 898-899, Oct., 1912).—A paper dealing with the visibility of point sources of light, and describing measurements of the same. A point source is taken as one whose linear dimensions subtend at the eye an angle less than the eye's resolving power, i.e. about $80''$ for a mean wave-length $0.5 + 10^{-8}$ mm. and pupular aperture 4.5 mm. The experiments showed that the visibility of a point source of light is independent of its intrinsic brightness and is proportional to its total candle-power; also that the visibility of a given source varies inversely as the square of its distance from the eye of the observer. The author's results for visibility of distant sources agree fairly closely with those calculated from the report of the Deutsche Seewarte of 1894. In the following table columns A and B give the candle-power (British) of white light required in clear air for visibility at the different ranges shown, A referring to the report of the Deutsche Seewarte, B to the authors' results.

Range.	A.	B.
1 sea-mile = 1855 m. approx.....	0.47	0.41
2 sea-miles.....	1.9 (0)	1.6 (0)
5 sea-miles.....	11. (8)	10. (0)

Experiments on the change of visibility of a point source when viewed through spectacle lenses showed that for distances greater than 8 m. positive lenses produced a marked loss of visibility amounting to 60 % in the case of a 1-dioptrie lens. Negative lenses for the same distances produced much less dimming; in the case of a green point source a 1-dioptrie (negative) lens produces a brightening of 20 %. Experiments on the effect of spherical aberration showed a somewhat improved definition of the image of the point when viewed through a smaller stop, but this had very little effect in lessening the relative loss of visibility of the green light when viewed through a positive lens. Further experiments were made in which the relative dimming of green and red point-sources was investigated. The results show how greatly the green light is dimmed, relatively to the red light, when viewed through any positive lens, and indicate that this is due mainly to the chromatic aberration of the eye.

A. W.

395. Image Errors of Optical Systems. E. Waetzmann. (Ann. d. Physik, 89. 5. pp. 1042-1052, Dec. 5, 1912).—Describes an interference method of investigating image errors of lenses or lens systems. The interference fringes used are those dealt with by Mascart and by Lummer, who gave the theory [Wied. Ann. 28. p. 518, 1884]. A plane-parallel glass plate, ABC, is placed at an angle of 45° with the principal axis of a lens L and with the middle point B on that axis. A plane mirror M is placed on the other side of the lens at its principal focus, and perpendicular to the principal axis. A narrow beam of parallel light incident at 45° on some point of the lower half AB of the glass plate gives by external and internal reflection two rays which pass through the lower half of the lens, are reflected from the mirror M, pass then through the upper half of the lens on to the upper half BC of the glass plate, and after external and internal reflection respectively are parallel to their original direction, and have no path difference. If a broad beam of parallel light falls on ABC the field is uniformly bright. But if the mirror M is turned slightly

from the null position the reflected rays fall at a different angle on the plate ABC; and the two rays above considered will have a path difference; so when a broad beam falls on ABC a system of interference curves are formed. Using a similar arrangement it is shown how the errors of lens systems having chromatic or spherical aberration may be investigated. Photographs are reproduced of typical cases. [See also Abstract No. 1690 (1911).] A. W.

396. Resolving Power of the Photographic Plate. E. Goldberg. (*Photographic Journ.* 52. pp. 800-816; Discussion, pp. 816-819, Nov., 1912.)—After a brief introduction, the subject is dealt with under the following headings:—Sharpness of reproduction and sharpness factor; determination of sharpness factor; turbidity curves and turbidity factor; relation between the sharpness curve and turbidity factor; limits of resolution. In the experiments a simple method, in which the lens is dispensed with, is employed. The principal practical conclusions arrived at are:—In all cases where, with a common or bad lenses the greatest possible sharpness is required, it is necessary to take care that a negative of the steepest possible gradation is obtained. For this purpose a "hard-working" emulsion must be used and full development given. The same rule also holds where the lens is of the best quality but the image is affected by the use of a filter or prism. In all these cases want of sharpness due to the resolving power of the plate is of small importance compared to the want of sharpness caused by the optical equipment, because it is far surpassed by the latter. An investigation of this point is being undertaken by the author. If a first-class lens is used to photograph and only the middle of the picture is required, where the aberrations of the rays are relatively small, then results differ as follows:—When fine structures, *e.g.* narrow neighbouring lines or points, fine drawings, reduced maps, etc., are photographed, where all light places of the picture possess the same intensity of light, there is no need to pay attention to the turbidity factor. With very short exposures the influence of the spreading of a single line or point (turbidity factor) has no value. On the other hand, the resolving limit of the plate in question in these cases plays an important part. Particular difficulty is offered by the exposures where fine lines or points of differing light intensity must be reproduced close together. Such cases are continually encountered with star and spectrum photography. Here, lines or points, the light-intensity of which is extraordinarily different (*e.g.* 1 : 1,000,000), lie closely together, so that the influence of the turbidity factor surpasses by far all other factors if a good lens is used. Short exposures are impossible, as the points of small light intensity cannot then be rendered, but with sufficiently long exposure the spreading of the disc is already so strong that the weakly lighted points merge into the image of the discs caused by the points of strong light-intensity and therefore cannot now be perceived. On that account plates must be used which have the smallest possible turbidity factor with regard to their resolving limit. At present, process and lantern plates unite a proportionately small degree of turbidity with a good resolving limit. It is, however, not impossible so to improve highly sensitive plates as regards the qualities discussed, that a good resolution can be attained both with short and long exposures.

A. E. G.

397. Action of Ink on the Photographic Plate. G. de Fontenay. (*Comptes Rendus*, 155. pp. 1610-1612, Dec. 30, 1912.)—Written or printed matter when placed for some time in contact with the sensitised surface of a photographic plate affects the latter in such a manner that, after developing, a positive or

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negative reduction is obtained. It is found that the precise nature of this phenomenon depends to a large extent upon the time of contact and the temperature, as also upon the nature of the ink and the paper surface. When all sources of error are eliminated it does not appear probable that any effect is attained which can be attributed to a purely chemical reaction, and there is no evidence that the results are produced by any new or particular radiation.

A. E. G.

398. Optical Behaviour of Centrifugalised Gold Hydrosols. **H. Robitschek.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1197-1212, July, 1912.)—For the purpose of finding if there is any connection between size of particle and colour, the author subjected solutions of gold hydrosols (some prepared by chemical reduction; some by the Bredig method) to centrifugalisation. It was found that the upper layer in all cases thereby became relatively more transparent for red than for blue light, whereas the lower layer is more transparent for blue than for red light, and appears to the eye alone of a dark blue colour. It appears, therefore, that the small particles of colloidal gold are more transparent for red light than for blue, whereas the larger particles are more transparent for blue. [Compare Abstract No. 242 (1912).]

A. F.

399. Molecular Symmetry. **A. Cotton.** (Comptes Rendus, 155. pp. 1282-1284, Dec. 9, 1912.)—Using the same notation as in the case of the corresponding crystal, if E_m be the ellipsoid representing the magnetic properties of the molecule, E_e the electrical, E_o the optical, and θ , the angle between the greatest axes of E_m and E_e ; then if magnetic and electric fields at an angle θ are applied simultaneously double refraction will be greatest when θ passes through θ_o . Thus θ_o is found. A study of the optical properties would therefore furnish a basis of classification of molecules according to the angles which the greatest axes of E_m and E_e make with the three axes of E_o , or in the case of the uniaxials, according to the form of the ellipsoid of revolution. The only ambiguity would be in the case of the biaxials (where θ_o would be 0), which might be confounded with the uniaxials.

J. M.

400. A Registering Micro-photometer. **P. P. Koch.** (Ann. d. Physik, 89. 4. pp. 705-751, Nov. 12, 1912.)—A complete account of the method of using the new apparatus is given and a description in detail of the various parts. There is also a series of results in tabular form and reproductions from photographs. The blackening curves obtained with the Hartmann and the registering micro-photometers are compared.

A. E. G.

401. Design of Spectrograph Objectives. **K. Schwarzschild.** (Preuss. Akad. Wiss. Berlin, Ber. 58. pp. 1220-1289, 1912.)—A short discussion is given of the conditions to be fulfilled in the design of objective lenses for spectrographs, in order to obtain the requisite definition over an extended field and throughout a given length of spectrum. Special reference is made to the performance of an objective for spectrograph III of the Potsdam Astrophysical Observatory.

C. P. B.

402. Theory of Moving Mirror. **A. Harnack.** (Ann. d. Physik, 89. 5. pp. 1058-1058, Dec. 5, 1912.)—A mathematical treatment which obtains results in agreement with those derived by A. Einstein (in 1905) on the relativity principle.

E. H. B.

403. Emission and Absorption of Stratified Bodies. **W. Voigt.** (Ann. d. Physik, 89. 6. pp. 1881-1407, Dec. 28, 1912.)—An analytical paper in which are

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obtained general formulæ for the emissions in all directions of an isotropic body arranged in parallel layers which change steadily and so slowly in density that internal reflections may be neglected though the corresponding absorptions are taken into account. [See Abstract No. 197 (1918).] E. H. B.

404. *Emission and Diffuse Reflection*. F. Jentzsch. (Ann. d. Physik, 89. 5. pp. 997-1041, Dec. 5, 1912. Extract from the Giessener Habilitationsschrift.)—A general discussion and mathematical treatment. Does not admit of brief abstract. A. W.

405. *Lummer Interference Plate*. F. Koláček. (Ann. d. Physik, 89. 6. pp. 1481-1490, Dec. 28, 1912.)—A detailed mathematical theory of the phenomena presented when working with a Lummer-Gehrcke interference spectroscope. E. H. B.

406. *Polarisation of Light due to passage through a Slit*. P. Zeeman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 599-601, Nov. 28, 1912.)—In a previous communication the author drew attention to the fact that by the polarising action of the grating the ratio of the observed intensities of the components of a triplet differs considerably from the ratio present in the light as it is emitted by the source [Ibid. Oct. 26, 1907]. Besides the action of the grating the polarising action of the slit affects the intensity ratio. Experiments are described which show that the vibrations perpendicular to a very narrow slit hardly traverse the slit; the ratio of intensities of the components of a triplet under observation gradually changes as the slit is narrowed. Hence errors may be introduced in observations. When the resolution of lines originally diffuse toward one side of the spectrum is investigated, apparent shifts and dissymmetrical separations may result. A quartz plate introduced before the slit of the spectroscope and giving a rotation of the plane of polarisation of 45° , eliminates at the same time both errors due to the polarising action of the grating and those caused by narrowness of the slit. A. W.

407. *Experiment on Polarised Light*. F. P. Liesegang. (Phys. Zeitschr. 18. pp. 1055-1056, Nov. 1, 1912. Paper read before the 84. Naturforscherversammlung, Münster, Sept., 1912.)—Describes with six figures the rotation of the plane of polarisation and its detection after repeated reflection at mirrors or piles of plates. E. H. B.

408. *Iron Spectrum for Wave-length References*. L. Glaser. (Zeitschr. wiss. Phot. 11. pp. 875-880, Dec., 1912.)—By an agreement among the members of the International Union for Co-operation in Solar Research the spectrum of iron was chosen as furnishing a series of International standards of wave-length, to be used as a scale for future spectrum references; some of the gaps in the iron spectrum were to be filled up by nickel lines. The author describes his work in photographing the spectrum of samples of nickel-steel of different composition, with references to plates of the spectra obtained. C. P. B.

409. *Ultra-violet Magnetic Rotation in Gases*. J. F. Sirks. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 778-788, Dec. 30, 1912.)—A modification of the apparatus previously used by Siertsema for investigating magnetic rotation in gases was made, so that Landau's half-shadow method of investigation could be employed. Also quartz was substituted for glass so that measurements could be made with ultra-violet light. The gases dealt
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with were oxygen, hydrogen, and CO_2 . Taking the rotatory constant for the mercury line $\lambda 5780$ to be unity, and combining the author's results with those previously obtained by Siertsema, the following table is obtained for the relative rotations for lines of various wave-lengths.

λ .	R. R ₅₇₈₀ .		
	Oxygen.	CO_2 .	Hydrogen.
5780	1.00	1.00	1.00
5460	1.08	1.12 (5)	1.12 (5)
4860	1.26 (5)	1.48 (5)	1.44
4860	1.50	1.80 (5)	1.81 (5)
4045	1.65 (5)	2.10	2.15
3665	1.96 (5)	2.57	2.64
3130	2.69 (5)	3.76	3.90
2805	3.86 (5)	4.77 (5)	5.14
2655	3.75 (5)	5.49	5.97 (5)
2535	—	6.19 (5)	6.67
2480	—	—	7.09
2400	—	—	7.76
2380	—	—	7.94

The oxygen curve deviates considerably from those for the other gases. On the assumption that ultra-violet refraction in hydrogen satisfies a formula of the type $n^2 = A + B/(\lambda^2 - \lambda_m^2)$, in which λ_m , the wave-length of the ultra-violet free vibration is taken to be 0.087μ , the following values have been calculated for c/m :—

λ in $\mu\mu$	589	405	318	265	248	238
$c/m \times 10^{-7}$...	1.77	1.78	1.81	1.85 (5)	1.86	1.87 (5)

The increase here found for c/m does not accord with the assumption of a single ultra-violet free vibration. A. W.

410. Wave-lengths of Neon. I. G. Priest. (Bureau of Standards, Bull. 8. pp. 539-544, Nov. 1, 1912.)—The 10 wave-lengths of neon given in this paper have been determined by the method of reflection fringes previously described [see Abstract No. 384 (1911)]. The lamps used were of the high-voltage "vacuum tube" type and were operated on a transformer circuit. The probable errors given are all less than 1 part in 10^7 . The reference standard is the wave-length of Cd red, taken as $6488.4696 \text{ I.}\text{\AA.}$ units. The value $5852.4862 \text{ I.}\text{\AA.}$ units for the bright yellow neon line is derived from the author's previous determination relative to Cd red by reducing to the present definition of the $\text{I.}\text{\AA.}$ unit. Errors of method and accuracy of results are discussed. The values found for the neon lines are as follows : 5852.4862, 5881.8958, 5944.8844, 6074.3883, 6096.1608, 6143.0600, 6266.4948, 6804.7929, 6882.9682, 6402.2392. A. W.

411. Ultra-violet Band of Water Vapour ($\lambda = 8064$). L. Grebe and O. Holtz. (Ann. d. Physik, 39. 6. pp. 1248-1250, Dec. 28, 1912.)—Discusses the origin and structure of the ultra-violet water-vapour band extending from $\lambda = 8063.547$ to $\lambda = 8291.687$. A table is given of the wave-lengths in international units of the lines of the band, and some of these are arranged in a series which approximately satisfies Deslandres' law. A. W.

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412. Spectroscopic Investigation of Ionium. F. Exner and E. Haschek. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1075-1077, June, 1912.)—From about 10,000 kg. of pitchblende residues about 180 gm. of material had been separated by A. v. Welsbach. Chemically it was principally thorium oxide, with a small proportion of the rare earths Y, Sc, and Ce. Meyer and v. Schweidler had investigated the radio-active properties of the material, and found an α -radiation of approximately 10,000 times that of pure Th. Assuming the transformation period of ionium to be only equal to that of Ra, the activity found would correspond to an ionium-content in the material of 2.5 per 1000. But from the results obtained by various workers it would appear that the transformation period of ionium is about 50 times that of Ra, which value would give an ionium-content of at any rate 10 %. If this were the case it would be natural to expect, if ionium is of an elementary nature, a characteristic ionium spectrum to be given. The authors' investigation of the arc spectrum of the material, using a large Rowland grating, showed, however, not a single line which did not belong to known elements of the group of rare earths. Besides the complete Th spectrum, the spectra of Ce and Sc were prominent, that of Y being also fairly strong. Traces of aldebaranium, cassiopeium, thulium, neoholmium, and europium were also found. It seems probable that the ionium-content of the material was in error, but it seems unlikely that the estimate of the transformation period is so much in error as would be required to explain the results obtained. The authors have also investigated a strongly active preparation of mesothorium and metallic radiolead, without finding any hitherto unknown lines. In radiolead a considerable thallium-content was found.

A. W.

413. Investigation of Spectrum of Ionium. A. S. Russell and R. Rossi. (Roy. Soc., Proc. Ser. A. 87. pp. 478-484, Dec. 13, 1912.)—The arc spectrum of a highly active preparation of ionium containing thorium has been investigated. No new lines due to ionium have been obtained. From this result it has been deduced that the period of ionium cannot exceed 12,000 years. This result, taken in conjunction with Soddy's results on the period of ionium, points to the existence of at least one new comparatively long-lived body between uranium and ionium in the disintegration series. [See Abstract No. 958 (1911) and preceding Abstract.]

A. W.

414. Absorption Spectrum of Tellurium Vapour. E. J. Evans. (Astrophys. Journ. 86. pp. 228-288, Oct., 1912.)—A continuation of previous work by the author and Antonoff [Abstract No. 48 (1912)] on the absorption spectrum of Te-vapour. The experimental arrangement was similar to that previously used. It was found that the bands in the absorption spectrum of Te extend from $\lambda 8900$ to about $\lambda 6000$. In addition to a band spectrum the vapour gives a general selective absorption. The absorption spectrum of Te is similar to that of Se, but compared with the spectrum of the latter it is displaced toward the red. For small pressures absorption bands are first photographed in the extreme violet ($\lambda 8900$), and as the pressure increases, absorption bands are also photographed in regions of greater wave-length. At pressures sufficient to show the presence of bands in the region $\lambda 5800$ - $\lambda 6000$, there is complete absorption in the violet and blue. When the pressure of the vapour is low, the absorption bands in the region $\lambda 8900$ - $\lambda 4500$ diminish in intensity with increase of temperature until they almost disappear at 1200°C . This result may be explained on the hypothesis that the absorption bands are due to complex molecules, which are present in Te-vapour at low temperatures.

These molecules are completely dissociated at high temperatures, and hence the absorption bands are not visible. The absorption spectra of a constant mass (0.002 gm.) of Te-vapour at 1000° and 1850° C. do not show any difference. Both spectra show the presence of bands between $\lambda 5800$ and $\lambda 6000$, and a continuous absorption from $\lambda 5800$ to $\lambda 8500$. The intensities of the bands are not affected by a change of temperature from 1000° to 1850° C. From the experimental results it is impossible to determine whether these bands are due to diatomic molecules or more complex ones. A. W.

415. Absorption Spectra of some Uranyl Salts. **A. Mazzucchelli** and **O. G. d'Alceo.** (Accad. Lincei, Atti, 21. pp. 850-854, Dec. 15, 1912.)—Reproductions are given of the absorption spectra of sodium uranyl oxalate with and without the addition of pyridine or hexamethylene-tetramine, and of sodium uranyl tartrate alone and in presence of pyridine, showing that the addition of the amine slightly alters the spectra of the uranyl salts, thus indicating chemical reaction between them. W. H. Si.

416. Band Spectra of Aluminium, Cadmium, Zinc. **E. E. Howson.** (Astrophys. Journ. 86. pp. 286-292, Nov., 1912.)—Band spectra were produced by the method described by Barnes [Abstract No. 1681 (1911)], and photographed with a Rowland concave grating of 14 ft. radius of curvature, using a comparison spectrum of iron. Tables are given of the component lines of the bands found, with suggested arrangement into series represented by the formula published by Fowler for magnesium, $\lambda m = a + bm + cm^2$. C. P. B.

417. Spectra of Low-potential Discharges in Air and Hydrogen. **G. S. Fulcher.** (Phys. Zeitschr. 18. pp. 1187-1142, Dec. 1, 1912.)—The author has previously investigated the light emitted by nitrogen, hydrogen, and oxygen molecules when bombarded by cathode rays with velocities corresponding to p.d.'s of from 500 to 5000 volts [see Abstract No. 872 (1912)]. The present paper describes a continuation of the work for low potentials. A Wehnelt cathode was used in a special apparatus, and the anode was perforated so that by applying a field a bundle of cathode rays of determinate velocity could be sent through the small hole into the chamber behind the anode, which was supplied with the gas under investigation. With the electrodes about 5 mm. apart and a sufficiently hot cathode, the minimum p.d.'s required were found to be: For hydrogen, 20 volts; for air, 27 volts; for oxygen, 45 volts; the pressure of the gas in the apparatus being of the order of 0.1 mm. of Hg. Tables are given of the principal band lines of hydrogen and of the intensity ratio of the lines in the hydrogen spectrum for high and low discharge potentials; photographs of the spectra of air and of hydrogen for different low potentials are also reproduced. The variations of the spectrum were similar in air and hydrogen, and it is concluded that the variations are due to the variations in the energy of the cathode rays; that the light is the result of the ionisation by the rays; and that the slow cathode rays ionising nitrogen give rise to both the positive and negative band spectra, whose intensity ratio depends on the energy of the ionising rays. It was also found that the light going from the space between the electrodes into the discharge chamber showed similar variations to those of the spectrum produced by the cathode rays, so that the light in the discharge chamber for these low potentials is principally due to ionisation by the cathode rays. The slowest rays (80 volts) give rise only to the positive nitrogen band

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spectrum, but the relative intensity of the negative bands increases very rapidly with the energy of the exciting beam, so that for 50 volts it is the stronger, and for higher potentials it greatly exceeds the positive band spectrum in intensity. In oxygen the spectrum for a discharge potential of 75 volts consists principally of the negative bands in the red and yellow, but the spark and series lines are also present. Reducing the potential to 45 volts caused the negative band to disappear.

A. W.

418. Band Spectrum of Mercury. E. Liese. (Zeitschr. wiss. Phot. 11. pp. 349-374, Dec., 1912.)—Using a quartz mercury lamp of the Heraeus type and the current from a transformer, which could give $\frac{1}{2}$ amp. at 2000 volts, the band spectrum of mercury was obtained and photographed. The wavelengths of the lines were determined by comparison with normal iron lines and are tabulated. The lines are arranged in a number of series, which approximately follow Deslandres' laws.

A. W.

419. Zeeman-effect. F. Paschen and E. Back. (Ann. d. Physik, 89. 5. pp. 897-932, Dec. 5, 1912.)—This paper deals with the following theory put forward to explain the deviation of some series lines from Preston's law: The vibrations corresponding to simple lines, whose magnetic separations are all normal, are stable; those causing doublets or triplets, etc., are unstable and forced. The smaller the difference in frequency the greater the instability. The cause of the emission of the particular arrangement of lines is at the same time the cause of their abnormal magnetic separation. A strong magnetic field may, in the case of close lines, upset the equilibrium and change the type in a single line with the resulting normal separation, which has been observed by the author in the case of the oxygen triplet 8947-4388, 8947-626, 8947-781, and in the spectra of other elements. Thus the normal triplet may come from a single line or a very close doublet or triplet, and appear where a complex magnetic type would be expected. The atomic internal forces work against the formation of groups of lines, so instead of a close doublet or triplet member of a series we may find a single line, e.g. the lithium lines perhaps.

J. M.

420. Zeeman-effect of Hydrogen Lines. F. Croze. (Comptes Rendus, 155. pp. 1607-1610, Dec. 80, 1912.)—According to F. Paschen and E. Back [see preceding Abstract] H_{α} , H_{β} , and H_{γ} do not give normal triplets, and the polarisation of the middle component in each case is incomplete. The author finds, on repeating his experiments [see Abstract No. 1867 (1912)], the same result as before, i.e. normal triplets for all three lines, and in addition for H.

J. M.

421. Magnetic Spectrum of Bromine. G. Ribaud. (Comptes Rendus, 155. pp. 900-908, Nov. 4, 1912.)—The author has obtained the following results:—The Zeeman-effect, if it exists, is under $\frac{1}{100}$ Å. in a field of 24,000 gauss. All the absorption lines of bromine show rotatory magnetic polarisation when the vapour is under suitable pressure, but the spectrum changes completely with change of pressure. To study the phenomenon in a monochromatic light, a much finer line than the green line from the mercury arc would be required, as within this width many absorption lines of bromine are contained. The transversal effect observed by Cotton for nitrous vapours is absent, at all events in a field of 28,000 gauss.

J. M.

422. D-Lines Emitted by Sodium Salts. K. Iwanow. (Phys. Zeitschr. 18. pp. 1112-1118, Nov. 15, 1912.)—The author has obtained, by the photographic-photometric method, the intensity curves for the emission lines D_1 and D_2 obtained from NaI, NaBr, NaCl, NaCO_3 , and NaNO_3 . He finds that the more stable compounds emit less light, but that as the temperature of the flame increases, the differences in the curves decrease. Making the flame more homogeneous by substituting a Méker for a Bunsen burner does not appreciably affect the dip in the centre of the curves corresponding to the reversal of the lines. The conclusions drawn are: (1) That temperature is the chief factor determining the emission of the D lines; (2) that the lines are emitted chiefly by neutral atoms, not by ions (from the fact that the lines are much the same from different salts, although the electrical conductivity varies); (3) that the inhomogeneity as regards emission and absorption at the outer edge of the flame accounts for the reversal of the lines. J. M.

423. Zeeman-effect. R. Fortrat. (Comptes Rendus, 155. pp. 1237-1239, Dec. 9, 1912.)—The author has measured the magnetic separation of the blue and of the ultra-violet zinc lines, which belong to the same series—

$$4680, 4722, 4810 \text{ give } \delta\lambda/\lambda^2 H = 1.8712 \times 10^{-4};$$

$$8086, 8018 \text{ give } \delta\lambda/\lambda^2 H = 1.872 \times 10^{-4},$$

furnishing a verification of Preston's law.

J. M.

424. Structure of Mercury Lines. H. Nagaoka and T. Takamine. (Phys. Soc., Proc. 25. pp. 1-29; Discussion, pp. 29-30, Dec., 1912.)—Describes an elaborate investigation of the structure of different mercury lines, using an echelon spectroscope crossed by a Lummer-Gehrcke plate. The authors find that the 5790 line consists of 8, the 5769 line of 4, the 5461 of 9, the 4859 of 11, the 4078 of 6, and the 4047 of 7 components, whose positions in general agree with those found by recent observers. A simple relation is indicated between the distances of the components from the principal line in each case, and a further relation between the quotient of each of these distances by the wave-length of the principal line is given, which holds for all the lines. The relative intensities of the component lines were determined by interposing an echelon photograph between a constant source of light and a linear thermopile, and noting the changes in the deflection of a galvanometer in series with the pile as the plate was moved across the face of the pile. In every case there appears to be a simple relation between the position and intensity of each component line. In the discussion C. H. Lees and Stansfield pointed out that ambiguity as to the order of echelon spectrum lines could easily be avoided by employing a prism to increase or decrease slightly the echelon dispersion. The latter also, among other things, called attention to the Fabry and Perot bands superposed on the ordinary spectrum due to the light reflected backwards and forwards between the plates. [See also Abstracts Nos. 1895 (1906) and 494 (1912).] A. W.

425. A New Measurement of the Optical Parameters of the Sodium Line D_1 . K. Iwanow. (Phys. Zeitschr. 18. pp. 1118-1128, Nov. 15, 1912.)— Q' , which is proportional to the number of dispersion-electrons per unit volume, is measured by the magnetic rotation of the plane of polarisation outside the Zeeman doublets. ν' , the damping constant of the electron motion, is determined from the intensity curve (obtained by the photographic-photometric method) for one component of the Zeeman doublets of the absorption line D_1 .

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According to H. A. Lorentz $\nu' \propto$ vapour density $\times \sqrt{\text{(absolute temperature)}}$. The author finds that $\nu' \propto \sqrt[3]{\text{(vapour density)}}$ approx., and concludes if the damping is only a force of the nature of friction, then all the sodium atoms do not take part in absorption and emission. The fraction active, he finds, decreases as more sodium salt is added to the flame. The max. absorption coefficient $= 2.4 \times 10^{-4}$. J. M.

426. Zeeman-effect. G. J. Elias. (Archives Musée Teyler, 1. Ser. 8. pp. 25-28, 1912.)—The author has made a study of the variation in the polarisation and intensity of the components of the emission lines chromium 520-620 and copper 510-575, when the angle between the magnetic field and the direction of the light is varied. J. M.

427. Convergence Frequency in Spectral Series. F. Sanford. (Astrophys. Journ. 86. pp. 255-262, Oct., 1912.)—The object of this paper is to show some relations between the convergence frequencies (A, in Kayser and Runge's formula) in the spectral series of certain atoms and some of their other physical properties. A. W.

428. Influence of Temperature on the Phosphorescence of Alkaline-earth Sulphides. H. E. Ives and M. Luckiesh. (Astrophys. Journ. 86. pp. 880-848, Nov., 1912.)—Experiments with the sulphides of Zn, BaBiK (Balmains' paint), and SrZnFl show that the decay of phosphorescence in these substances is represented by Becquerel's formula $I^x = a + bt$, where x is a function of the temperature, independent of the quantitative composition of the phosphore, and a and b are functions of the composition and heat-treatment of the sulphide. The flashing-up under the influence of infra-red vibrations is greatest at low temperatures, rapidly declining with rise of temperature. For ZnS the effects of infra-red rays and heat during excitation and the early stages of decay are opposite, that of the infra-red rays being upon the permanent process only. It is suggested that the phenomena may be explained by taking into account the complex character of the phosphores, and ascribing to each component its own temperature-scale, the early part of the decay being given chiefly by the high-temperature components, the later part by the low. [See also Abstract No. 161 (1912).] W. H. S.

429. Excitation of Phosphorescent Alkaline Earths by Canal Rays. H. Baerwald. (Ann. d. Physik, 89. 4. pp. 849-886, Nov. 12, 1912.)—The effects obtained by previous observers are dealt with at some length. A complete account of the present experimental arrangements and methods of making observations is also given. As a result it is found that in the excitation of the phosphorescent alkaline earths by canal rays the charged particles play a much more important part than the uncharged. The nature of the charge, however, does not appear to make any difference, the action with positive or negative being of relatively the same degree. A distinction is also obtained between the excitation of phosphorescence and the chemical action of the canal rays on the light-sensitive layer, by which only the number of particles and not their charged condition comes in question. The emission of phosphorescence appears to be essentially an electrical phenomenon. A. E. G.

430. Intensity of α -Radiation from Uranium. S. Meyer and F. Paneth. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1408-1412, July, 1912. Communication VOL. XVI.—A.—1918.

from the Inst. f. Radiumforschung.)—The authors have made ionisation measurements with thin films of U_3O_8 and Ra with the object of determining the relative ionisation produced by the Ur and Ra in the mineral. The results obtained for the ratio (ionisation Ur)/(ionisation Ra) is 100/57·8 under conditions in which all the α -radiation to one side is utilised. This value agrees with McCoy's value [Abstract No. 421 (1907)] but not with Boltwood's which is 100/45 [Abstract No. 154 (1909)]. The theoretical value deduced from the ranges of UrI, UrII, and Ra is calculated to be 100/58, and the agreement with the observed value precludes the possibility of the presence of a third α -radiating substance in ordinary uranium, and also affords additional proof that UrY is only a side product. E. M.

431. *γ -Rays Excited by the β -Rays of Radium.* J. Chadwick. (Phil. Mag. 24. pp. 594-600, Oct., 1912.)—It has been shown by Gray [Abstract No. 1709 (1912)] that when the β -rays of RaE impinge on any material they excite γ -rays. In the present paper this result has been extended to the β -rays from RaEm in equilibrium. A quantity of RaEm contained in a thin glass tube was placed in a strong converging magnetic field produced by using suitably shaped pole-pieces of an electromagnet. The β -rays were thus concentrated on a metal sheet and any excited γ -radiation could be measured in an ionisation chamber where the leak was balanced on a principle similar to that of Rutherford and Chadwick [Abstract No. 1201 (1912)]. In the experiments the primary γ -rays were cut down to less than 5 % by a slab of lead. Excited γ -rays were found for all the materials examined, the relative amounts varying from 75 for a thick sheet of Al to 100 for uranium. The amount was, however, only 0·8 % of the primary γ -radiation from the source even after correcting for the fact that only a fraction of the β -particles fall on the radiator. Measurements of the absorption coefficient of the excited γ -radiation showed it to be more penetrating with increase of atomic weight of radiator, although even for lead its absorption coefficient was about three times that for the primary γ -radiation of the source. If it be supposed that the γ -rays from radio-active matter are produced by the β -rays, the experiments bring out clearly the high efficiency of the transformation of β -rays into γ -rays during the disintegration of the atom of RaC, compared with the efficiency of the conversion of β -rays into γ -rays when the former fall on matter of high atomic weight. As Gray has shown, the exact converse holds for the product RaE. E. M.

432. *Ranges of α -Particles from Thorium and Actinium Products.* H. Geiger and J. M. Nuttall. (Phil. Mag. 24. pp. 647-654, Oct., 1912.)—In the present investigation the authors have continued their work on the determination of the ranges of the α -particles from different radio-active products [Abstracts Nos. 188, 861 (1912)]. For the Th and Ac families the estimations are difficult owing to the short periods of some of the products and the consequent impossibility of separating them. Thus AcEm and AcA are always associated with AcX. In the method employed two bell-jars are placed opposite each other and separated by a large sheet of thin and uniform mica. The source is placed at the bottom of the lower bell-jar with a grid of cylindrical tubes to canalise the α -particles. The two bell-jars are air-tight, the lower one containing air at adjustable pressure, and the upper one containing hydrogen. By altering the pressure in the lower bell-jar a Bragg ionisation curve is obtained by measurements in a shallow ionisation chamber in the upper bell-jar. In the case of the Th-products a very active thin layer of

ThX was used as a source, a piece of mica being placed directly over it to prevent the escape of ThEm. Thus the ionisation curve obtained is the resultant of the effect of the α -particles from ThX, Em, A, C₁, and C₂. By separate observation of the ionisation curve for the active deposit alone, (C₁ + C₂), the curve is analysed and the ranges are deduced. The following table gives the collected values together with others. Column 4 gives the initial velocities calculated from the formula $v^2 = aR$, where R denotes the range and a is a constant. The results verify the linear relation between the logarithms of the transformation constants and the logarithms of the ranges of α -particles from products of the same radio-active family.

RANGES OF α -PARTICLES.

Substance.	Ranges at		Initial Velocity.
	0° C.	15° C.	
Uranium 1.....	2·37 cm.	2·50 cm.	1·47 $10^9 \frac{\text{cm.}}{\text{sec.}}$
Uranium 2.....	2·75	2·90	1·54
Ionium	2·85	3·00	1·56
Radium	3·18	3·30	1·61
Ra Emanation	3·94	4·18	1·74
Radium A	4·50	4·75	1·82
Radium C	6·57	6·94	2·06
Radium F	8·58	8·77	1·88
Thorium	2·58	2·72	1·51
Radiothorium	3·67	3·87	1·70
Thorium X	4·08	4·30	1·75
Th Emanation	4·74	5·00	1·85
Thorium A	5·40	5·70	1·98
Thorium C ₁	4·55	4·80	1·82
Thorium C ₂	8·16	8·60	2·21
Radioactinium	4·86	4·60	1·80
Actinium X	4·17	4·40	1·77
Act Emanation.....	5·40	5·70	1·98
Actinium A	6·16	6·50	2·02
Actinium C	5·12	5·40	1·89

E. M.

433. *Origin of β - and γ -Rays from Radio-active Substances.* E. Rutherford. (Phil. Mag. 24. pp. 453-462, Oct., and pp. 893-894, Dec., 1912. Le Radium, 9. pp. 837-841, Oct., 1912.)—The experiments of v. Baeyer, Hahn, and Meitner, and later by Danyasz [Abstracts Nos. 1849 (1911), 1194 (1912)] have shown that for many β -radiating products the β -rays are not altogether homogeneous but consist of a number of homogeneous groups of rays each of which is characterised by a characteristic velocity. This complexity appears to be best shown by products which also emit penetrating γ -rays. Using as a β -ray source a thin-walled glass tube containing a large quantity of RaEm, Danyasz found that RaB and RaC together emit nearly 80 groups of homogeneous rays. Notwithstanding this great complexity the experiments of Moseley have shown that the actual number of β -particles emitted is about that to be expected if both RaB and RaC emit only one β -particle per disintegrating atom. In order to account for these results the author considers the hypothesis that the disintegration of each

atom of the same substance takes place in exactly the same way with the emission of the same amount of energy, but that the energy of the β -particle may be decreased by definite but different amounts due to the transformations of its energy in its passage through the atomic system in which it originates. The energy subtracted from the escaping β -particle in this way is further supposed to be transformed into the γ -rays. Evidence in support of this hypothesis is obtained from a consideration of Barkla's results on characteristic X-radiations, for the γ -rays of RaC have a coefficient of absorption in Al, in good agreement with that calculated for an atomic weight 214 by an extrapolation from the results for the elements examined, *i.e.* from Ca to Ce. An examination of the energies of the β -rays corresponding to the definite groups of velocity for RaB and RaC shows most of them to be expressible by the formula $pE_1 + qE_2$, where p has integral values between 0 and 9; q integral values from 0 to 2; $E_1 = 1.12 \times 10^{12}$ ergs and $E_2 = 0.856 \times 10^{12}$ ergs. The remainder, which presumably are those of RaB, show an approximately constant difference of energy $E_3 = 0.178 \times 10^{12}$ ergs. From the results of Whiddington and Chapman [Abstracts Nos. 1088, 1259 (1912), etc.] it is calculated that the energy of an electron necessary to excite the characteristic X-radiations of series K and L in an atom of atomic weight 214 are 1.27×10^{12} ergs and 0.190×10^{12} ergs respectively, which are not very different from the above values of E_1 and E_2 . Considering these results in relation to the author's theory that an atom consists of a central concentrated positive charge with rings of electrons round it possibly rotating in one plane, it is conceivable that the atomic instability which leads to the expulsion of a β -particle is mainly confined to one of the rings and leads to the escape of a β -particle from this ring with great velocity. The β -particle in escaping from the atom passes through the electronic distribution external to it, and in traversing each ring may in some cases lose part of its energy in exciting one or more γ -rays which have a definite energy characteristic of each ring. This idea finds general support from the known properties of γ -rays. E. M.

434. Further Experiments on δ -Rays. N. Campbell. (Phil. Mag. 24. pp. 527-540, Oct., 1912.)—The experiments show that, in the case of the current carried by δ -rays from metals, the relation between the current and the p.d. is independent of the temperature of the electrodes from the temperature of liquid air to the softening point of the glass used. Further, the current is determined rather by the total p.d. between the electrodes than by the electric field in the space between them. The author therefore concludes that the δ -rays must be emitted originally with a finite velocity. Most of the δ -rays appear to have velocities less than 8 volts, but a few may have velocities as high as 10 or 20 volts. The velocities, however, are independent of the material on which the α -particles fall and also of the velocity of the α -particles. The author does not consider it necessary to assume that all the δ -rays come from a layer of air on the surface of the materials. In a note the author states that results of further experiments have shown that Röntgen-rays liberate δ -rays precisely similar to those liberated by α -rays. E. M.

435. Radio-activity of Terrestrial Surface Materials. J. Joly. (Phil. Mag. 24. pp. 694-705, Oct., 1912.)—It has recently been well established that the fusion method of determining the Ra-content of rocks is more reliable than the old solution method and leads to somewhat higher values. In this method the emanation is taken directly from the pulverised rock while this is being decomposed by the alkaline carbonates at temperatures rising to

1100° C. or more. In the present paper results are given of many new determinations, and from these the subject of terrestrial radio-activity is discussed generally. For igneous rocks the mean Ra-contents per 10^{13} gm. are found to be : Acid, 8.01 ; intermediate, 2.57 ; basic, 1.28 ; general mean, 2.5. For sediments the mean is 1.5, and the measurements are such as to indicate a certain substantial difference between the two classes. For igneous rocks the rate of development of heat per gm. due to both Ra and Th is calculated to be 2.5×10^{-13} gm. cals. per sec. To account for the observed heat gradient at the surface of the earth a material of this degree of radio-activity can only be supposed to extend downwards to about 17 km. Various cognate questions are discussed, particularly relating to suboceanic sediments.

E. M.

436. Comparison of Coefficients of Diffusion of Thorium and Actinium Emanations, with a Note on their Periods of Transformation. M[ay] S. Leslie. (Phil. Mag. 24. pp. 687-647, Oct., 1912.)—The values hitherto found for the diffusion coefficients of the radio-active emanations differ considerably from one another, and are in general higher than would be expected from the probable molecular weights calculated on the basis of the disintegration theory. The usual method employed in the cases of Th and Ac is to suspend a plate near the emanating substance for a time sufficient for the active deposit to attain equilibrium. The distribution of the active deposit at different distances from the source is measured and taken as proportional to the density of emanation atoms. The diffusion coefficient is calculated from the formula $p = p_0 e^{-\sqrt{(\lambda x^2/D)}}$, where p_0 is the initial concentration, p the concentration at a point of distance x , λ the radio-active transformation constant, and D the coefficient of diffusion. In the present series of experiments it is found that different results are obtained according as the plate is uncharged or is charged negatively, the difference being traced to diffusion of the active-deposit particles after their formation from the emanation atoms. Further, even with a charged plate the apparent diffusion coefficient obtained depends largely on the intensity of the source of emanation employed, the inference being that in presence of a large amount of ionisation some of the active-deposit particles are neutralised, and owing to their diffusion the gradient of active-deposit particles does not represent the true gradient of emanation, the difference depending largely on the arrangement of the apparatus. Maximum limits to the true values of the coefficients of diffusion for Th and Ac emanations are assigned to be 0.085 and 0.098 respectively. Experiments under as nearly identical conditions as the periods of the two emanations will allow, however, indicate that the molecular weights of the two gases are probably very nearly equal. In an additional note to the paper experiments are described in which the transformation periods of Th and Ac emanations are found to be 54 and 8.9 secs. respectively, in good agreement with the values generally accepted. E. M.

437. Radio-activity of Hot Springs of Kinosaki, Tazima (Japan). D. Ishitani and K. Manabe. (Mathematico-Physical Soc., Tōkyō, Proc. 6. No. 21. pp. 808-812, Nov., 1912.)—The paper contains further results on the emanation-content of various waters [see Abstract No. 86 (1918)]. It is found that the greater the depth of an artesian well, the greater the emanation-content. This also explains results which show that hot springs contain much greater amounts of emanation than cooler ones. One particular spring at 68° C. gave 2700×10^{-12} curies of emanation per litre. E. M.

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438. *Magnification of Capillary Thread of Thermometers.* W. Meissner. (Zeitschr. Instrumentenk. 82. pp. 871-876, Dec., 1912. Communication from the Physikal. Techn.-Reichsanstalt.)—Discusses the best form of prismatic cross-section for mercury-in-glass clinical thermometers in order to obtain as large as possible magnification of the capillary thread. A. W.

439. *Expansion of Water below 0° C.* J. F. Mohler. (Phys. Rev. 85. pp. 286-288, Sept., 1912. Abstract of paper read before the Amer. Physical Soc., Washington, Dec., 1911.)—Water in a capillary tube can be cooled considerably below 0° C. without freezing. Using this peculiarity the author enclosed freshly-distilled water in capillary tubes of diameters varying from 0.2 mm. to 0.4 mm. One end of a tube is sealed; then the tube is immersed in a freezing mixture and the change in volume noted. In this way water was taken to -18° C. without freezing, the volume becoming 1.008078 of its amount at 4° C. The changes in volume thus found are greater than those found for a shorter range by Desprez and by Pierre and Weidner. P. E. S.

440. *Thermal Conductivity of Metals.* S. Pagliani. (N. Cimento, 4. Ser. 6. pp. 482-497, Dec., 1912.)—Taking the best values obtained for various metals, the latter may be arranged in a series of decreasing thermal conductivity and reflecting power, or increasing emissive power. They then fall into groups according to the periodic system as follows: Ag, Cu, Au (1); Al (8); Mg, Zn, Cd (2); Rh, Pd, Ir, Pt, Fe, Ni (8); Mn (7); Sn, Pb (4); W, Mo, Cr (6); Va, Sb, Bi, Ta, Nb (6). The emissive power of many metals of the 5th and 6th groups has been utilised for incandescent filaments; and the oxides of those of the 4th group for solid luminous conductors. E. E. F.

441. *Ratio of Specific Heats.* A. Leduc. (Comptes Rendus, 155. pp. 909-911, Nov. 4, 1912.)—Describes a new method for the determination of this ratio. A large flask is used provided with a tap. The temperatures are ascertained by a thermometer and the pressures of the contained gas inferred from the masses found by weighings of the flask at the different stages of the operation of filling and adiabatic expansion. Considerable accuracy is claimed for the method, and its mathematical theory is given. E. H. B.

442. *Emissivity of Solid and Liquid Gold.* C. M. Stubbs and E. B. R. Prideaux. (Roy. Soc., Proc. Ser. A. 87. pp. 451-465, Oct. 31, 1912.)—Describes a spectrophotometric comparison of the emissivity of solid and liquid gold at high temperatures with that of a full radiator, the measurements extending throughout the visible spectrum. A sharp discontinuity in the emissivity takes place at the melting-point, the liquid gold emitting more strongly than the solid in the red, and less in the extreme blue. The shape of the "relative emissivity" curves is quite different in the two cases. The curve of relative emissivity of solid gold at high temperatures is similar to that of absorptivity at low temperatures as determined from reflectivity measurements; whether it is identical, in which case the temperature

coefficient of the absorptivity would be zero, could not be absolutely determined, owing to the change of structure which a polished surface undergoes on heating. No temperature coefficient of relative emissivity could be detected for the liquid metal, through a range of over 100° . Black-body temperatures of solid and liquid gold at the melting-point have been calculated. It is shown that the general equation expressing the radiation of a selective radiator is of the form $E_{\lambda} = f(\lambda, T) c_1 \lambda^{-5} e^{-c_2/\lambda T}$, which in the case of gold and other metals cannot be reduced to the form of Wien's equation for a full radiator with changed values of the constants. A. W.

443. The Psychrometric Formula. G. Smeal. (Roy. Soc. Victoria, Proc. 25, pp. 151-166, 1912.)—The observations discussed are in continuation of a series previously carried out to test a modification of the psychrometric formula proposed by Ekholm, viz. $x = \eta f - AB(t - t')$ [see Abstract No. 1491 (1912)]. The conclusion reached in the former paper was that the insertion of the coefficient η was not justified. The present work was undertaken in order to test the formula under low humidities, the former observations all having been made under conditions of fairly high humidity, that is, above 50 per cent. The range now covered is from 18 to 95 per cent. The method employed was exactly similar to that previously adopted, three wet bulb thermometers covered respectively with linen, cotton, and silk being used. The differences between the readings of these wet bulbs were again found to be quite unimportant and the conclusion is thus reached that the value of η is not perceptibly dependent upon the nature of the covering of the wet bulb. The most suitable values for η and A in the formula have been determined by the method of least squares and are found to be $\eta = 0.9877$, $A = 0.0006967$; while assuming η to be unity and applying the method of least squares to the determination of A in the simpler formula the value is found to be $A = 0.0007282$. Applying each of these formulæ to the whole series of observations it is found that there is no practical difference in the accuracy obtained by the two methods for either vapour pressure or relative humidity. The formula $x = f - 0.00072 B(t - t')$ is therefore presented as that most satisfactory for general use. J. S. D.

444. Specific Heats of Crystallised Salts. F. G. Jackson. (Amer. Chem. Soc., Journ. 84, pp. 1470-1480, Nov., 1912.)—The author finds the following values for the specific heat of ice and of a number of crystalline salts:—

	-78.4° to 0°	-188° to 0°	-188° to -78.4°
Ice	0.424 ± 0.002	0.337 ± 0.001	0.277 ± 0.003 (calc.)
	-78.4° to $+22^{\circ}$	-190° to $+22^{\circ}$	-190° to -78.4°
$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	0.236 ± 0.001	0.202 ± 0.006	0.169 ± 0.007
CuSO_4	0.127 ± 0.008	0.120 ± 0.008	0.114 ± 0.010
$\text{Cu}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	0.249 ± 0.008	0.280 ± 0.004	0.212 ± 0.012
$\text{CuNa}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$...	0.186 ± 0.010	0.153 ± 0.008	0.121 ± 0.013
$\text{CuK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$...	0.218 ± 0.001	0.174 ± 0.007	0.135 ± 0.008
$(\text{NH}_4)_2\text{SO}_4$	0.330 ± 0.001	0.283 ± 0.003	0.241 ± 0.004
Na_2SO_4	0.197 ± 0.006	0.167 ± 0.002	0.140 ± 0.008
K_2SO_4	0.171 ± 0.008	0.147 ± 0.008	0.125 ± 0.011
$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	0.287 ± 0.001	0.215 ± 0.008	0.150 ± 0.004
$\text{CdSO}_4 \cdot \frac{2}{3}\text{H}_2\text{O}$	0.168 ± 0.001	0.135 ± 0.001	0.105 ± 0.002
$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	0.292 ± 0.002	0.234 ± 0.002	0.182 ± 0.004

The author has calculated the molecular heats, and finds that the molecular heats of hydrated and double salts are almost the same as the sum of the factors, except in the case of copper sodium sulphate. A. F.

445. *Free Electrons and Specific Heat.* O. Richter. (Ann. d. Physik, 89. 6. pp. 1590-1608, Dec. 23, 1912.)—A series of Bi-Sn and Bi-Pb alloys were examined with regard to their specific heat, in connection with Schulze's determinations of their thermal and electrical conductivity. The successive addition of Sn to Bi produces a uniform increase in the specific heat, whereas the successive addition of Pb to Bi produces a maximum of 0.082519 when equal weights are taken, with a straight slope either way. The departure from the rule of mixtures is in the opposite direction in the conductivities. The author concludes that in these two alloys, at all events, the free electrons do not sensibly contribute to the specific heat. E. E. F.

446. *Theory of Specific Heats.* P. Debye. (Ann. d. Physik, 89. 4. pp. 789-889, Nov. 12, 1912.)—A detailed review of the previous work, experimental and mathematical from which are drawn the following conclusions:— (1) For a solid body there is no simple frequency of the atoms as originally supposed by Einstein. The body is characterised rather by a whole spectrum of vibrations. (2) The spectrum consists of a finite number of lines, viz. three times the atomic number. The lines of the lowest frequency are the ordinary acoustical vibrations. (3) The falling-off of the spectrum may be characterised by the density of the lines estimated per change in frequency ($d\nu$). This is found to be proportional to $\nu^3 d\nu$. The proportionality factor is calculable from the elastic constants of the material. (4) From (3) a formula for the energy-content and for the specific heat may be derived, if in the sense of the *quantum* theory we ascribe to each degree of freedom the energy $h\nu/(e^{h\nu/kT} - 1)$, in which h = working quantum = 7.1×10^{-27} erg sec. k = Boltzmann's constant = 1.47×10^{-16} erg, T is absolute temperature. (5) For each monatomic body an expression is found for the specific heat which involves the ratio θ/T , where θ is a temperature characteristic of the body in question. The form of the function is the same for all monatomic bodies. (6) At low temperature the specific heat of *all* bodies is proportional to T^3 . The energy-content is then proportional to T^4 . The limiting law distinguishes the present author's results from the formulæ of Einstein and of Nernst and Lindemann. (7) The comparison of this formulæ with observations on diamond, Al, Cu, Ag, and Pb show a good accord. (8) The Nernst-Lindemann formulæ may be regarded as an approximation to that of the present author. (9) The characteristic temperature θ may be derived from the electric constants. [See Abstract No. 1707 (1911) and next Abstract.]

E. H. B.

447. *Atomic Heats.* W. Nernst and F. A. Lindemann. (Preuss. Akad. Wiss. Berlin, Ber. 52. pp. 1160-1171, 1912.)—This is the sixth of a series of papers on specific heat investigations. It reviews the formulæ given by Einstein, the authors and P. Debye for specific heats [see preceding Abstract], also the results of experiment and theory for Al, Cu, Ag, diamond, KCl, and NaCl. [See Abstracts Nos. 1524 and 1707 (1911).] E. H. B.

448. *Chemical Affinities.* W. Nernst. (Preuss. Akad. Wiss. Berlin, Ber. 52. pp. 1172-1176, 1912.)—The seventh of the series of papers dealing with specific heats. This one discusses mathematically the relations between chemical affinity A , absolute temperature T , and the *Wärmelönung* U .

E. H. B.

449. *Specific Heats of Solids at High Temperatures.* M. v. Pirani. (Deutsch. Phys. Gesell., Verh. 14. 28. pp. 1087-1064, Dec. 15, 1912.)—The VOL. XVI.—A.—1918.

specific heats of tantalum and tungsten were determined by observing the energy necessary to heat the metal to a high temperature. The temperature was measured by a thermo-couple or by the change of resistance of the metal with the temperature. The method was applied to the tantalum and tungsten filaments utilised in the manufacture of metallic filament lamps. For details the original paper must be consulted. [See also Abstract No. 250 (1908).] F. J. B.

450. High-temperature Gas Thermometry. A. L. Day, R. B. Sosman, and E. T. Allen. (Carnegie Inst. of Washington, Geophys. Lab. pp. 1-129, 1911.)—A complete record is given of the redetermination of the absolute temperature scale from 400° to 1100° and its extension to 1550° . The investigation extended over 5 years and included experiments with thermo-elements between zero and the temperature of melting Pt. The object of the gas-thermometer problem at present is to increase the accuracy of the measurements and to extend their range. Recent improvements have been : electric heating, resulting in accurate controlling of the temperature, and the use of the metal bulb with its definite and measurable expansion coefficient and its capability of holding the expanding gas without loss. The gas now used does not diffuse through the bulb or react with it chemically ; does not dissociate within the limits of practicable measurement, and its expansion can be expressed with reasonable certainty in terms of the Kelvin thermodynamic scale. The source of the errors in the thermo-elements, and a way to avoid them have also been discovered. In 1904 Holborn at the Reichsanstalt increased the range of the scale as far as 1600° C., the probable error of the new portion being 10° . The present publication is a record of experimental measurements covering an unusually wide range of details which do not admit of brief classification. The errors in previous work with the nitrogen thermometer have been reduced in the present investigation to about $\frac{1}{4}$ th of their former magnitude, and the certainty of their evaluation is proportionately increased. The points chiefly attended to are the following : (1) To provide a uniform temperature about the bulb by a suitable arrangement of electric heating coils and diaphragms. (2) To enclose the furnace in a gas-tight bomb in which the pressure outside the bulb can be maintained equal to that within for all temperatures. The advantages are : (a) deformation of the bulb is avoided ; (b) by using the same gas within and without there is no tendency to diffuse through the bulb wall ; (c) the initial pressure may be varied within considerable limits, thus increasing the scope and sensitiveness of the manometer. The sensitiveness was about three times that of the Reichsanstalt. (8) The expansion of the bulb material was determined with great care and is probably accurate within 0.5 per cent. (4) The unheated space between the bulb and the manometer has been reduced until the total correction in this hitherto uncertain region amounts to less than 4° at 1100° . An error of 5 per cent. in the determination of its volume or temperature distribution is therefore practically negligible. These changes probably reduce the uncertainty in the correction factor required for the gas thermometer about 1100° to less than $\frac{1}{5}$ th of its former magnitude. The chief source of present uncertainty is the temperature distribution over the surface of the bulb in an air-bath. For the higher temperatures no satisfactory liquid bath has been found. A table is given (as below) of standard melting-points with an estimate of the degree of trustworthiness to be accorded to each. Beside it is placed for comparison the present Reichsanstalt scale. No indication

of a limit to the temperature attainable with the nitrogen thermometer or to its ultimate accuracy was discovered during the investigation. [In a paper read before the Soc. franç. de Physique (Journ. de Physique, 2. Ser. 5. pp. 727-749, Sept.; 831-844, Oct., and pp. 899-911, Nov., 1912) the authors cover much the same ground, but more briefly.]

Substance.	Point.	Atmosphere.	Crucible.	Temperature.	Reichsanstalt Scale.
Zinc	Melting and freezing	Air	Graphite	$418.2 \pm 0.8^\circ$	419.0
Antimony	Melting and freezing	Carbon monoxide	"	639.2 ± 0.5	630.6
Silver	Melting and freezing	Carbon monoxide	"	980.0 ± 0.7	961.5
Gold	Melting and freezing	Carbon monoxide	"	1063.4 ± 0.8	1064.0
Copper	Melting and freezing	Carbon monoxide	"	1083.6 ± 0.8	1084.1
Diopside (pure)	Melting	Air	Platinum	1391.4 ± 1.5	
Nickel	Melting and freezing	Hydrogen and nitrogen	Magnesia and magnesium aluminate	1453.3 ± 2.0	
Cobalt	Melting and freezing	Hydrogen and nitrogen	Magnesia	1489.8 ± 2.0	1575
Palladium	Melting and freezing	Air	Pure magnesia	1549.2 ± 2.0	
Anorthite (pure)	Melting	"	Platinum	1549.5 ± 2.0	
Cadmium	Melting and freezing	"	Graphite	320.0 ± 0.3	321.7
Aluminium ..	Freezing	Carbon monoxide	"	658.0 ± 0.6	657
Li_2SiO_3	Melting	Air	Platinum	1201.0 ± 1	
Platinum	"	"	—	$\begin{pmatrix} 1752 \\ 1755 \end{pmatrix} \pm 5$	

J. J. S.

451. *Constancy of Sulphur Point.* **W. Meissner.** (Ann. d. Physik, 39. 6. pp. 1280-1242, Dec. 23, 1912. Communication from the Physikal-Techn. Reichsanstalt.)—Discusses the various forms of screen and other arrangements needed for observing accurately the sulphur boiling-point. The paper is illustrated by a number of diagrams and gives tables showing the errors involved by certain modifications in the arrangements. These errors are often only a few hundredths of a degree. An equipment with electric resistance heating and a platinum-resistance thermometer is described in detail with a sectional figure. [See Abstract No. 1646 (1908).]

E. H. B.

452. *Change in the Boiling-points of Nitrogen Trioxide and Tetraoxide on Drying.* **H. B. Baker and M. Baker.** (Chem. Soc., Journ. 101. pp. 2889-2841, Dec., 1912.)—A specimen of nitrogen trioxide which in 1907 failed to boil rapidly at 16° was kept for three years over phosphoric oxide and was then sealed off in bulbs by immersing the whole in liquid air, two of these being placed in tubes containing nitrogen dried by contact with phosphoric oxide. After six months the bulbs were broken and the boiling-point of the liquid at atmospheric pressure (757 mm.) was found to be 48° instead of -2° , which is the boiling-point of the ordinary liquid. On cooling the tube to $+10^\circ$ green drops formed at once, showing undissociated nitrogen trioxide to be present. When a small quantity of nitrogen, dried by passing through a long column of phosphoric oxide, was admitted to the apparatus the very small quantity of moisture it contained produced vigorous dissociation and the expansion blew out the stopper. It has also been found that dried

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nitrogen tetroxide can be kept at a temperature of $+69^{\circ}$ without boiling, although the ordinary boiling-point is $+22^{\circ}$. The explanation of these abnormal boiling-points is probably to be found in the difference of complexity in the liquids. It is probable that the liquid nitrogen trioxide has a more complex molecule than N_2O_3 , and in one case the vapour density indicated a mixture of three molecules of N_4O_6 with one of N_2O_3 . It is further possible that a more complex molecule exists in the liquid below -2° , since the colour changes distinctly from olive-green to bright blue at this temperature. Further experiments are being made on the boiling-points of dissociable substances.

T. H. P.

453. Some Physical Constants of Sulphur Trioxide. Melting- and Boiling-points, Density, Coefficient of Expansion, and Molecular Weights. D. M. Lichty. (Amer. Chem. Soc., Journ. 84. pp. 1440–1448, Nov., 1912. Paper read at the 8th Internat. Congress of Applied Chemistry, New York, Sept., 1912.)—The author finds the melting-point of α -sulphur trioxide under atmospheric pressure to be 16.79° . The boiling-point was found to be 44.28° at 740.7 mm.; 44.21° at 740.0 mm.; 44.86° at 744.5 mm. From these values the b.p. at 760 mm. is calculated to be 44.88° , in place of 46° , the value usually given. The values for the density are as follows:—

Temp.	11.8°	15°	20°	25°	30°	35°	40°	46°
Density	1.9467	1.9422	1.9229	1.9020	1.8798	1.8569	1.8324	1.7921

The coefficients of expansion are also given for a series of temperature-ranges, e.g. between 15° and 20° it is 0.002005, between 20° and 25° 0.002204. The author does not find that there is any temperature at which there is a slow attainment of constancy of volume at fixed temperature such as was found by Schenck at 85.8° . He shows that there exists a solid sulphur trioxide, apparently identical with the ordinary solid form, and designated the β -form, the molecular weight of which in phosphorus oxychloride is 80, the same as that of the persistently liquid α -variety.

A. F.

454. On the Triple Point of Methane. C. A. Crommelin. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. p. 668, Nov. 28, 1912. Communication No. 181B from the Physical Lab., Leiden.)—The following values of temperature and pressure at the triple point of methane were found: $t = -188.15$ K.; $p = 7.0$ cm.

A. F.

455. On the Second Virial Coefficient for Diatomic Gases. W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 417–481, Oct. 24, 1912. Supplement No. 25 to communications from the Phys. Lab., Leiden.)—The most important results yielded by the present investigation are summarised as follows:—The experimental results with regard to the second virial coefficient for hydrogen above -100° C. are consistent with the assumption of rigid spheres with constant doublets. Below -100° C. hydrogen exhibits deviations from this behaviour which finally become considerable. Below the Boyle point hydrogen is found to correspond with argon and also with helium in so far as the experimental data for helium at present available allow of any definite conclusion. It appears, therefore, that between -100° C. and -280° C. as far as B is concerned the thermal behaviour of hydrogen also approaches that of a monatomic substance and eventually becomes the same, as was found by Eucken to be the case with its caloric behaviour. It was also found that, as far as the second virial coefficient is concerned the thermal

behaviour of oxygen between 0° and 200° C., as deduced from Amagat's observations, corresponds with that of a system of rigid spheres of central symmetry, each with a doublet of constant moment at its centre. For nitrogen, on the other hand, within the same temperature region, important deviations were found from the behaviour of rigid spheres of central structure each with an electric doublet of constant moment at its centre. With nitrogen in that temperature region, the dependence of B on the temperature corresponds with that deduced from the assumption that the van der Waals quantities a_∞ and b_∞ are constant; but then the values given by Bestelmeyer and Valentine for B from 81° to 85° K. differ greatly from this. A. F.

456. Heat of Vaporisation of Metals. A. Wehnelt and C. Musceleanu. (Deutsch. Phys. Gesell., Verh. 14. 22. pp. 1082-1084, Nov. 30, 1912.)—The method adopted is to use the metal as anode in a vacuum tube. The cathode consists of platinum foil of suitable size on which CaO is placed. It is so arranged that the max. electrical energy occurs at the anode, so as to bring about the melting and vaporisation of the metal under observation. The anode is weighed before the experiment, and then by means of the loss of weight, and calculations based upon the energy used in vaporising the metal, the total heat and the latent heat of vaporisation are determined. The results so obtained are as follows:—

Metal.	Measured Total Heat of Vaporisation.	Latent Heat of Vaporisation Calculated from Total Heat.
Hg	78.8	68.6
Cd	222.0	181.0
Zn	439.5	365.8
Mg	2027.0	1700.0
Bi	177.5	161.5

A. E. G.

457. New Forms of Whirling Gaseous Combustion and their Analogy with certain Astronomical Phenomena. J. Meunier. (Comptes Rendus, 155. pp. 1248-1246, Dec. 9, 1912.)—When a gas jet is brought up to a wide flame, the gas-pressure of which has been increased to one-tenth of that of the jet [see Abstract No. 888 (1912)], the point of the latter is bent back owing to the resistance of the non-inflammable interior of the other flame. The luminous centre of the spiral undergoes circular enlargement and exhibits a brilliancy showing regular alternations which recall the phenomena observed with temporary stars; its colour varies from yellow to reddish. A mechanical explanation is suggested for these flame phenomena, which are compared with those of spiral nebulae. T. H. P.

458. Ignition of Electrolytic Gas by the Electric Discharge. H. F. Coward, C. Cooper, and C. H. Warburton. (Chem. Soc., Journ. 101. pp. 2278-2287, Dec., 1912.)—The ignition temperature is the lowest temperature at which the rapid inflammation of a gas mixture occurs in the absence of a catalyst. The experiments concern chiefly the minimum gas-pressure at which ignition occurs with different spark-gaps and batteries in different-
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sized vessels. The size and shape of the vessel (cylinder or globe of glass) have no influence except at very low pressures (5 to 10 mm.) and in very small vessels, nor has the position of the electrodes in the vessel. The ignition pressure is lowered by covering the electrodes with glass except the tips, especially when the bare tips are enlarged. As the spark-gap is lengthened the ignition pressure passes through a minimum. A flame which filled a globe of 570 cm.³ has been produced at 5 mm., a flame which travelled through a cylinder, 2 m. long, at 8 mm. pressure; these figures are considerably lower than previous observations. The combustion is never complete because of the cooling effect of the glass walls, and the amount of the unburnt gas varied in two globes inversely as the initial pressure of the gas. H. B.

459. The Gas Equation. S. D. Wicksell. (Phil. Mag. 24. pp. 869-876, Dec., 1912.)—Expresses the constants a and b in van der Waals' gas equation as functions of the temperature, thus getting a gas equation that covers the case of Clausius and others. The equation is put into a more convenient form by means of series, and a and b are expressed in terms of known and measurable quantities. That the deviation from the ideal gas equation is proportional to the pressure is expressed by the relation—

$$P'v' - R\theta/(P'v' - R\theta) = P'/P''.$$

This equation includes no quantity characteristic of the gas, and therefore can be regarded as a general gas law to a second approximation, if Boyle-Mariotte-Gay Lussac's law is regarded as the first approximation. E. E. F.

460. Constant of the Stefan Law of Radiation. W. H. Westphal. (Deutsch. Phys. Gesell., Verh. 14. 21. pp. 987-1012, Nov. 15, 1912.)—The constant of the Stefan radiation law was determined from measurements of the consumption of electric energy of a blackened body radiating heat in air at low pressure, the temperatures ranging from 350° to 425° abs. The effect of heat conduction of the air was eliminated by a difference method. The mean of all the results obtained gives for the constant the value $\sigma = 5.54 \times 10^{-12}$ watt/cm.² deg.⁴ ± 0.5 %. From Planck's radiation theory and this value for σ , using the value $b = 1.437$ found by Warburg, Hupka, and Müller, the following constants are determined:—

Elementary quantum of electricity	$e = 4.68 \times 10^{-10}$ e.s. unit.
Constant of entropy equation	$k = 1.841 \times 10^{-16}$.
Elementary "Wirkungsquantum"	$h = 6.455 \times 10^{-27}$.
Number of molecules per c.cm. of a gas	$N = 2.77 \times 10^{19}$.

A. W.

461. Calculation of Internal Energy from the Characteristic Equation. E. Kohl. (Monatshefte f. Math. u. Physik, 24. pp. 159-182, 1918.)—In a previous paper the relationship $P = T \int \frac{\partial \epsilon / \partial V}{T^2} dT + T\psi(V)$ was established,

where P is the reversible pressure, ϵ the internal energy, V the volume, and T the temperature of a body. The integration is carried out with ϵ as a function of T and V , V being a parameter of T . The assumption of ϵ as a function of T and V is the basis of the author's deductions. By inserting the above value for P in the Clausius modification of the characteristic equation, expressions for the heat of evaporation, the specific heats at constant volume and pressure, and the heat of compression at constant

temperature are obtained. As examples the heats of evaporation of ethyl ether, water, carbon disulphide, and ethyl alcohol are discussed, and the values obtained compared with those afforded by the formulæ of Hirn and Winkelmann. For ether and water the values diverge with increasing temperature, for carbon disulphide the formulæ are in excellent agreement, while for alcohol the disparity between theory and experiment is most pronounced. The specific heats for the same four liquids are also considered. From the results the author concludes that the internal-energy expression rests on firm ground, and that any deviation between theory and experiment is due to inexactness of the modified characteristic equation. The internal energy thus appears to be a definite function of T and V , whose form depends upon the nature of the substance.

H. H. Ho.

402. Radiation Theory. D. Hilbert. (Phys. Zeitschr. 13, pp. 1056-1064; Discussion, p. 1064, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml. Münster, Sept., 1912.)—A treatment of the foundations of elementary radiation theory by aid of integral equations. The most important of Kirchhoff's laws is thus obtained as a mathematical truth, from which the other laws then follow.

E. H. B.

403. Universal Significance of the Elementary Working-quantum. O. Sackur. (Deutsch. Phys. Gesell., Verh. 14. 21. pp. 951-959, Nov. 15, 1912. Ann. d. Physik, 40. 1. pp. 67-86, Dec. 31, 1912.)—A mathematical treatment regarding the entropy constants of gases, and using Sommerfeld's hypothesis that every action exerted in nature is an integral multiple of the elementary working-quantum (*Wirkungsquantum*) h . The analysis leads to an equation expressing the vapour-pressure at different temperatures, which, on comparison with calorimetrically determined quantities, gives a new and direct confirmation of Nernst's theorems.

E. H. B.

404. Photochemical Law and the Molecular Theory of Radiation. J. Ishiwara. (Phys. Zeitschr. 13, pp. 1142-1151, Dec. 1, 1912.)—A theoretical treatment on thermodynamic lines with special reference to Einstein's work. [Abstract No. 1689 (1912).]

L. H. W.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

465. *Magnetic Effect of Rotating Bodies.* P. Lebedew. (Ann. d. Physik, 89. 4. pp. 840-848, Nov. 12, 1912.)—Describes experiments designed with the view of detecting a distant magnetic effect, if any exists, of rotating bodies. With rings of ebonite, brass, aluminium, water, and benzol *no perceptible* deflection of the magnetometer was obtained. E. H. B.

466. *Charges on Metallic Dust.* A. Mayer. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1097-1188, June, 1912.)—An endeavour to harmonise the results of E. Ehrenhaft and of R. H. Millikan on the determination of the elementary electric charges on very fine particles of metal. The data of the above experimentalists are repeated and examined in detail, but no definite quantitative result is derived from them. [See Abstract No. 1560 (1912).] E. H. B.

467. *Nuclei Charges.* K. Przibram. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 949-984, June, 1912.)—A summary of the data from previous experimental papers and a derivation therefrom of the elementary electric charge. The values differ according to whether one or another correction to Stokes' law is used. Thus Millikan's correction is characterised by $A = 0.815$, McKeehan's by $A = 1.00$. On Stokes' law $A = 0$, yet other views give $A = 0.68$ and $A = 1.3$. The final means are as follows:—

Values of A : 0.815, 1.0, 1.3,
Values of $e \times 10^{10}$: 4.957, 4.600, 4.21.

The paper contains about 25 pages of tables. [See Abstracts Nos. 686 (1911); 57 and 854 (1912).] E. H. B.

468. *Electrification by Spraying Liquids.* C. Christiansen. (Ann. d. Physik, 40. 1. pp. 107-187, Dec. 31, 1912.)—This paper deals with a series of researches on the electrification occurring when fine drops of liquid are squirted on to a solid wall, by Lenard called *waterfall* electricity, the present author preferring the term *Balloelektrizität*. This is the first communication of a series and presents in 41 tables the results of tests on a great number of liquids. E. H. B.

469. *Problems relating to Two Spheres.* G. B. Jeffery. (Roy. Soc., Proc. Ser. A. 87. pp. 109-120, Aug. 18, 1912.)—A form of the solution of Laplace's equation suitable for problems relating to two spheres is found. The solution is applied to finding expressions for the potential and capacity of two spherical conductors. Tables of the numerical values of the capacity coefficients for two equal spheres are given and also a table for the capacity of a sphere in the presence of an infinite conducting plane. **A. Russell.** (Ibid. pp. 485-487, Dec. 18, 1912.)—Russell shows that the numerical values of the capacity coefficients for equal spheres can be computed very easily when the spheres are close together. He recalculates the tables and gives a formula for calculating the capacity between a sphere and a plane when they are very close together. A. R.

470. Determination of Electrostatic Capacities by Conjugate Functions. J. W. Woodrow. (Phys. Rev. 35, pp. 484-448, Dec., 1912.)—The author obtains by means of conjugate functions the formula for the capacity, (1) of a wire parallel to two planes intersecting at right angles, (2) of two wires parallel to the earth and one directly above the other, and (8) of three parallel wires arranged so as to be at the corners of an equilateral triangle. He finds the capacity of a two-core cable by a suitable transformation and also finds the capacity of the three-core clover-leaf type of cable discussed in Russell's "Alternating Currents," Vol. I., Chap. V. A. R.

471. The Problem of Two Electrified Spherical Conductors. G. R. Dean. (Phys. Rev. 35, pp. 459-469, Dec., 1912.)—The author by a suitable transformation of Laplace's equation obtains a solution for the potential at all points in the neighbourhood of two electrified spheres having unequal radii. The solution is in the form of an infinite series of zonal harmonics. All the mathematical work is clearly given and simplified formula are found both for the potential and the potential gradient in the neighbourhood of two equal spheres having equal and opposite charges of electricity. A. R.

472. Dust Figures produced by Electric Sparks. E. H. Barton and W. B. Kilby. (Phil. Mag. 24, pp. 728-736, Nov., 1912.)—Lycopodium powder was used to obtain striæ by means of electric sparks from an influence machine or induction coil, the support being glass or metal. The striæ showed many analogies to optical phenomena, including reflection, refraction, interference, and diffraction. Distinct foci were obtained by reflection from concave surfaces. A "whispering gallery" effect was observed in the shape of striæ normal to a surface for a considerable distance, without divergence of the wave-normals. Twenty reproductions of these dust figures are given. E. E. F.

473. High Value of Induced Radio-activity and of Conductivity in the Cordilleras. W. Knoche. (Phys. Zeitschr. 13, pp. 1221-1222, Dec. 15, 1912.)—Observations of radio-activity by Elster and Geitel's method at the mine Las Conde near Santiago (8500-8600 m. above sea-level) gave very large values, and observations of conductivity on clear and dry days gave a mean value of about 23×10^{-4} e.s. unit. The high conductivity was a consequence of the presence of an abnormally large number of ions, while at the same time the velocity of the ions was not far from normal. Probably the large values are due to the high altitude and to intense solar radiation. R. C.

474. Atmospheric Electricity. Observations at Seeham in Summer, 1911. E. v. Schweidler. (Akad. Wiss. Wien, Ber. 121. 2a, pp. 1297-1304, July, 1912.)—The observations [see Abstract No. 190 (1912)] were continued in July to Sept., 1911. The dissipation curves of 1911 (very dry, hot summer) differed from those of previous years as to the diurnal variations. The ionisation due to the penetrating radiation was measured in a zinc vessel, not hermetically sealed, and in a copper vessel, hermetically sealed, on shore, in the air above the lake and also in the shallow water of the lake (Mattsee); the two apparatus did not agree, even when close to one another. There was a decrease of the radiation above the water and an increase after rain; the radiation at Seeham was much smaller than at Innsbruck. H. B.

475. Measurements of Atmospheric Electricity during the Partial Solar Eclipse on April 17, 1912. A. Brommer. (Akad. Wiss. Wien, Ber. 121. 2a, VOL. XVI.—A.—1913.

pp. 985-995, June, 1912. Communication from the Inst. f. Radiumforschung.)—Observations of atmospheric electricity made during previous solar eclipses have yielded contradictory results in the hands of different experimenters and on different occasions, and have given rise to the belief that no direct connection exists between the variations in solar radiation and the electric elements. Observations were made by the author of the numbers and velocities of the positive and negative ions in the atmosphere near Vienna at intervals during the day of the eclipse and the following day. Meteorologically both days were similar, as they opened with light clouds, which gradually cleared away in the afternoon. On the 17th April a slight increase in relative humidity took place during the time of eclipse, otherwise there was nothing specially remarkable about the meteorological records. Of the electrical measurements the most noteworthy were those of positive and negative charge per m.², which are proportional to the numbers of positive and negative ions. The positive charge showed a gradual decrease from 0.54 to 0.26 e.s. unit near the time of maximum phase, followed by an equally gradual increase to 0.52 at the end of the eclipse. The negative charge showed similar characteristics, the corresponding values being 0.52, 0.22, and 0.54. The variations before and after the eclipse were slight, and they were small and irregular on the following day. The velocities of the ions decreased slightly during the first part of the eclipse, and remained steady afterwards. On both days the positive usually exceeded the negative charge and the value of q , the ratio of positive to negative charge, was therefore usually greater than 1; but large variations in this quantity occurred at the beginning and towards the end of the eclipse. The variations in the charges are so well defined and regular that the author finds it difficult to avoid the conclusion that there was a *direct* connection between the eclipse and the number of ions. R. C.

476. *Variations of the Electrical Conductivity of the Atmosphere and of the Air-earth Current at Potsdam.* K. Kähler. (Phys. Zeitschr. 18. pp. 1216-1221, Dec. 15, 1912.)—Continuous registration of electrical conductivity as well as potential gradient and charge on rain has been made at Potsdam since 1909. For recording conductivity two blackened copper wires 20 m. long are suspended horizontally between hard rubber insulators and connected each with a Benndorf electrometer. The upper wire, which is charged positively, is $1\frac{1}{2}$ m. above the ground; the lower, negatively-charged wire is 1 m. below the upper, i.e. $\frac{1}{2}$ m. above the ground. Each wire is surrounded by an earthed wire-netting $\frac{1}{2}$ m. away. Six times an hour the wires are charged up to + 220 and - 220 volts respectively, and the fall of potential during the 10 mins. succeeding each charge is recorded by the electrometer, and therefrom the conductivities of the negative and positive ions (λ_- and λ_+) are deduced. On "quiet" days the mean conductivity ($\lambda_+ + \lambda_-$) is 0.95×10^{-4} e.s. unit, the mean potential gradient is 254 volts/m., and the mean value of q ($= \lambda_+ / \lambda_-$) is 1.16. From the mean values of conductivity and potential gradient is deduced the mean air-earth current. It amounts to 71×10^{-8} e.s. unit, i.e. 2.4×10^{-16} amp./cm.². Solar radiation is found to exercise a powerful influence upon the variations of the electric elements. For example, the seasonal variation of air-earth current shows a 'maximum in winter or spring, and a minimum in summer or autumn; and the daily variation in summer has a pronounced minimum in the mid-day with maximum in the evening and morning. The excess of positive ions is greater in winter than in summer and smaller at mid-day than at night, q is smaller at

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mid-day near the ground than higher up. Fog almost always produces a large diminution in conductivity, while dust frequently causes the potential gradient to become negative, without affecting the conductivity. This appears to be due to very immobile ions.

R. C.

477. Stokes' Law and Electronic Charge. J. Roux. (*Comptes Rendus*, 155. pp. 1490-1498, Dec. 28, 1912.)—Discusses a correction to Stokes' law and the percentage difference it would introduce in the value obtained for the electronic charge on Millikan's plan. [See Abstract No. 948 (1911).]

E. H. B.

DISCHARGE AND OSCILLATIONS.

478. Gas Ionisation by the Schumann Rays. L. and E. Bloch. (*Comptes Rendus*, 155. pp. 908-906, Nov. 4, 1912.)—Ordinary ultra-violet rays produce the Hertz-effect when they strike a metal, but do not ionise dust-free air. The author finds that the Schumann rays produce by ionisation an effect at least five times greater, at atmospheric pressure, and 25 times greater at pressures of 8 cm., 2 cm., 1 cm. than the Hertz-effect of ordinary rays. In a vacuum the ionisation ceases, but the Hertz effect of the Schumann rays is at least five times greater than that of ordinary rays.

J. M.

479. Ionisation of Air by Quartz Mercury Arc. L. and E. Bloch. (*Comptes Rendus*, 155. pp. 1076-1078, Nov. 25, 1912.)—Preliminary experiments showed that the photoelectric effect on brass of the light from a Cooper Hewitt mercury lamp is reduced very considerably by the interposition of a quartz plate 1 mm. thick, and that a plate of 0.25 mm. produced a sensible diminution. The rays intercepted are evidently those which have been separated spectroscopically by Tian [see Abstract No. 1857 (1912)], and which correspond to the beginning of the absorption band of quartz. These rays are only feebly absorbed by air, for in the authors' experiments there was a distance of about 1 m. between the arc and the photoelectric receiver. But it was thought these rays, or others more refrangible, might cause appreciable ionisation of the air in the neighbourhood of the arc. The arc was enclosed in a zinc box, which had two openings, one for ingress, the other for egress of air. Through the box was sent a current of filtered air, which passed thence to a condenser connected to an electrometer. As soon as the arc was started, the condenser received electric charges. Measurements were carried out exclusively on the positive charges, whose presence is a certain indication of volume ionisation. These charges could not be attributed to diffused ultra-violet light, which was eliminated as completely as possible; and no effect was produced in absence of the current of air; also it was not due to the high temperature of the quartz tube, for this was kept from getting too hot. The electrometer deflection followed almost instantaneously the striking of the arc. It is concluded that the light from the mercury arc can ionise air, and that the ionising action shows itself for the rays which are far from being entirely absorbed by quartz. [See preceding Abstract.]

A. W.

480. Simultaneous Action of Magnetism and Gravitation upon Ionised Gases. Gouy. (*Comptes Rendus*, 155. p. 1060, Nov. 25, 1912.) **C. G. Darwin.** (*Ibid.* pp. 1145-1146, Dec. 2, 1912.)—Gouy mentions that the apparent failure of Carnot's principle [see Abstract No. 216 (1913)] will not occur if the ions are generated on the walls of the vessel, say, at a high temperature. Then

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the motion of the ions from the bottom will be opposed to that of the ions in the middle of the gas, and an exact compensation may take place. Darwin adduces reasons why Carnot's principle should remain valid in any case. Liouville's dynamical theorem is not affected by the presence, in the equations of motion, of gyrostatic or magnetic terms. If, then, the distribution of ions and molecules is fortuitous to begin with, there will be no tendency to a systematic or non-fortuitous distribution, and therefore there will be no separation of the ions, and no "spontaneous" current. E. E. F.

481. High Velocities of Photoelectric Electrons. R. Pohl and P. Pringsheim. (Deutsch. Phys. Gesell., Verh. 14. 21. pp. 974-982, Nov. 15, 1912.)—Millikan obtained values ranging from 10 to 100 times those formerly observed for the initial velocity of electrons set free by the action of ultra-violet light of wave-lengths 180 to 800 μ . Experiments are now described which indicate that these abnormal velocities are to be attributed to the disturbing action of electric oscillations. A. E. G.

482. Ionisation and Photo-electricity of Vapours of Alkali Metals. S. H. Anderson. (Phys. Rev. 85. pp. 289-284, Oct., 1912.)—When potassium vapour alone is between the electrodes (Ni electrodes used) of a vacuum tube there is no conductivity of the usual type at 25° or 50°. At 100°, with a p.d. of 700 volts, there is a current arising from ionisation by the electric field. There is nothing of the character of spontaneous ionisation. In a tube with two similar electrodes, exhausted to the highest vacuum, there is a current of the order of 10^{-12} amp. in a direction opposite to the electric field, which increases with the field. This phenomenon is affected by light and is diminished by the presence of K-vapour. It confirms Woodrow's observation of the emission of $+$ -particles from alkali metals. At temperatures above 50° this emission is, in the dark, large compared with the electron current. But for higher temperatures the emission of electrons is predominant for p.d.'s of 800 volts and more. Probably the critical temperature is 82°, the melting-point of K. At 25° the photoelectric current is 25 times the current due to the emission of $+$ -particles, but at higher temperatures it becomes very small in comparison with the positive emission, unless an auxiliary voltage is applied. The max. vapour pressure possible for K at 25° is 0.0587 mm. of Hg. E. E. F.

483. Theory of Photoelectric Action. O. W. Richardson. (Phil. Mag. 24. pp. 570-574, Oct., 1912.)—Gives a second theory [see Abstract No. 1414 (1912)] which covers more facts than the first. This solution is dependent on the assumption that the reflection of electrons can be neglected. This means that the only energy lost by the electrons is used up in overcoming the work of the forces which tend to retain them within the interior of the substances. Then the kinetic energy of the escaped electrons is equal to that which they acquire by the action of light *minus* the work which they have to do to escape. It is clear that the energy which they acquire under the influence of light is $h\nu$, where h is Planck's action constant. It has the same value for all the electrons liberated by light of the same frequency; any difference in the energy of the electrons liberated by monochromatic light is therefore due to the effect of collisions of the escaping electrons within the substance. E. E. F.

484. Reflection of Slow Cathode Rays. L. Houllévigüe. (Comptes Rendus, 155. pp. 1146-1149, Dec. 2, 1912.)—The author has previously shown [see VOL. XVI.—A.—1918.

Abstract No. 1085 (1912)] that the electrons emitted by an incandescent carbon filament can give under the action of an electric field created by a p.d. of about one hundred volts, a very clearly outlined cathode bundle. Experiments are now described which show that by systematically varying the electric state in the interior of a receiver the effects of apparent reflection of a cathode bundle can be reproduced at will, as can also the suppression of this reflection. There is thus no doubt that the observed reflection at the internal surface of the glass is due to the fact that this surface is maintained at a certain critical potential, and that this result is brought about automatically by successive reflections. When the glass is at a potential higher than the critical value it absorbs the electrons, and a lowering of potential is thus brought about: this goes on until the potential is reduced to the critical value when reflection again takes place. These successive reflections at the interior of a receiver give birth to a diffused light: when the cathodic bundle is no longer reflected the light disappears.

A. E. G.

485. *Light given out by Gases under the Influence of Kathode Rays.* E. Gehrcke and R. Seeliger. (Deutsch. Phys. Gesell., Verh. 14. 22. pp. 1028-1081, Nov. 30, 1912. Communication from the Physikal.-Techn. Reichsanstalt.)—This forms a continuation of experiments previously described [see Abstract No. 908 (1912)], improved apparatus being used by means of which the paths of the cathode rays are greatly elongated. In the first part, observations of the colour envelope of the cathode rays in nitrogen, hydrogen, helium, argon, mercury, CO, and coal gas lead to the conclusion that, in general, elongated cathode rays show a threefold colour envelope. The colours observed depend upon the pressure and the current. Comparative experiments on the positive column in nitrogen, hydrogen, mercury, and helium are next described. Every light-striation has in general three different coloured parts. The sharpest formed layers occur in hydrogen and the least sharp in helium; in the latter the colour and form is very variable. From the results it is also clear that the colour series of the separate parts of a layer are not always in accord with those of a lengthened-out or accelerated cathode ray. Lastly the spectra of different parts of an elongated cathode ray in hydrogen, nitrogen, helium, and mercury are examined. These observations show that the colour envelope of the lengthened-out cathode rays depends on the properties of the luminous particles.

A. E. G.

486. *Absorption of Gas in Vacuum Tubes.* S. E. Hill. (Phys. Soc., Proc. 25. pp. 85-48; Discussion, p. 48, Dec., 1912. Electrician, 70. pp. 228-229, Nov. 15, 1912. Abstract.)—It has long been known that the continuous discharge of a current through an ordinary vacuum tube causes a gradual diminution of pressure. No experiments have yet been described which enable it to be determined whether this action is of a chemical nature or merely due to physical absorption. In the present experiments the electrodeless ring discharge is used because the ions are not shot directly into the glass as in the case with metal electrodes, and any possibility of electrode action is done away with, both as regards absorption and evolution of gas. The bulbs used are made of soda, Bohemian, lead, and Jena glass, and the absorptions at different pressures are noted and curves plotted. Continued passage of the current causes a "saturation" effect in all these glasses. The decreasing order of absorption for both air and hydrogen is: soda, lead, Bohemian, Jena. After two months none of the bulbs had recovered their absorptive power. If the action is chemical it is natural to expect various oxidation products to be

formed when air is used. This is proved to be the case, for when tested with hydrogen to reduce these products, a large initial absorption takes place. That reduction actually occurs is proved by the increased absorption of oxygen when air is readmitted. The peculiar deposits on the necks of the bulbs is further evidence in support of the chemical nature of the phenomenon, as is also the fact, established by Soddy and Mackenzie, that the inert gases show correspondingly small absorption. In the *discussion*, **A. A. Campbell Swinton** pointed out that in Soddy's and the present experiments, forms of electric discharge were employed with which the amount of heat communicated to the glass would be very great as compared with the amount of cathode-ray bombardment; whereas in his experiments the converse was the case. He therefore thinks it probable that the cause of the absorption of gas is not necessarily the same in both cases. **A. E. G.**

487. Influence of Nature of Kathode on the Length of the Crookes Dark Space. **F. W. Aston.** (Roy. Soc., Proc. Ser. A. 87. pp. 487-451, Oct. 81, 1912.)—The kathode-fall is widely different for different metals, and it was thought probable that the length of the dark space might also be affected. On this account the following metallic kathodes are experimented with: Mg, Al, Fe, Cu, Zn, Ag, Sn, Pt, and Pb, and in addition kathodes of C, Hg, H_2SO_4 and also perforated kathodes of Zn are used. The gases employed are oxygen and hydrogen, the former on account of the abnormal sharpness of the edge of its dark space, the latter for contrast and because it exhibits the primary kathode dark space; the anode throughout is of Al. A simple form of apparatus, particularly adapted for changing the kathode with minimum risk of accident, is described. Results obtained show that the relations between the values of pressure, voltage, current and the length of the dark space as determined for plane kathodes of many different materials, satisfy the same form of equation as those previously given for Al, the constants varying considerably. Roughness of the kathode surface does not appear to affect the discharge, if the dimensions of the irregularities are small compared with the length of the dark space. The length of the dark space is shown in the cases examined to be greatest for Ag and least for Mg, the metals following the same order as in the kathode-fall. The rate of change of length of the dark space with change of current density at the surface of the kathode appears to be the same for all kathodes. Difficulties in the way of arriving at a satisfactory explanation of these and other data connected with the dark space are indicated and briefly discussed. **A. E. G.**

488. Observations on the Glow Discharge in very Pure Gases. **G. Gehlhoff.** (Deutsch. Phys. Gesell., Verh. 14. 21. pp. 960-969, Nov. 15, 1912.)—Gehlhoff and Rottgardt found that in the presence of vapours of the alkali metals the kathode-fall and the discharge potential in a vacuum tube were very small [see Abstract No. 1815 (1910)]; and, further, the author has found that potassium vapour purifies the gas. It might therefore be expected that the low kathode-fall and total potential is caused by a purification of the gas by the electric discharge in potassium vapour and the deposit of metallic potassium on the kathode. The present experiments establish these assumptions and at the same time show in what a very marked degree the electrical properties of a gas depend upon its purity. Thus in pure hydrogen the striations are not removed, while in pure gases of the He group and in pure nitrogen a completely unstriated discharge occurs. **A. E. G.**

489. *Phenomena of Electric Pseudo-resonance.* G. Claude. (*Comptes Rendus*, 155. pp. 968-971, Nov. 11, 1912.)—When neon tubes are connected in series with condensers, it has been found that as the number of these tubes increases, the current intensity also increases: thus, with the condenser there is a current of 0.7 amp.; with one tube, 0.88 amp.; 1.10 amps. with two, 1.22 with three, and 1.26 amps. with four tubes in series. A fifth tube not only makes it difficult to illuminate, but causes a diminution of the current. It is further found, when the light of one of the tubes is examined photometrically, that although the current increases enormously the luminosity of the tube diminishes, although the brightness of an incandescent lamp placed in circuit is greatly increased. This indicates that the luminosity of the tube, unlike that of the incandescent lamp, does not depend on the efficient intensity, but on the average intensity which diminishes as the number of tubes is increased. The theoretical consideration of these observations is dealt with at some length.

A. E. G.

490. *Bending of Electric Waves round a Large Sphere.* J. W. Nicholson. (*Phil. Mag.* 24. pp. 755-765, Nov., 1912.)—A continuation of work referred to in Abstracts Nos. 382 (1912) and 1828 (1910). The first part of the present paper deals with points near the axis in the region of brightness, it being shown that the preceding investigation does not fail near the axis. The second part gives a general investigation of the shadow. The results render more emphatic the earlier conclusion that the explanation of long-distance radio-telegraphy must be sought elsewhere than in diffraction.

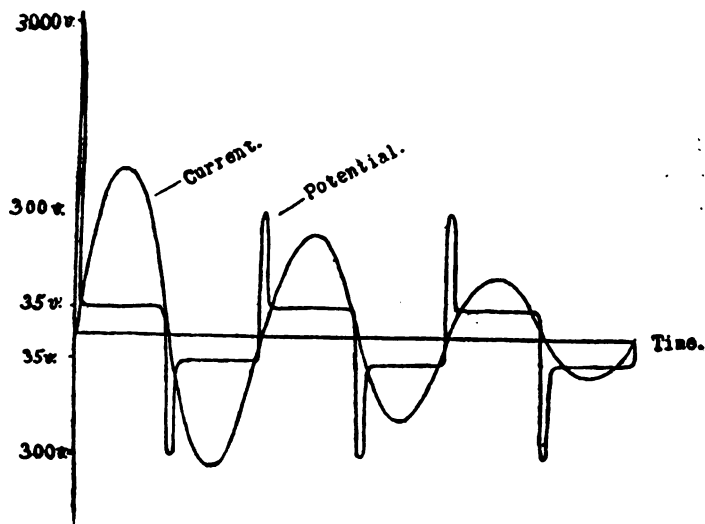
T. P. B.

491. *Effect produced by an Obstacle on a Train of Electric Waves.* H. M. Macdonald. (*Roy. Soc., Phil. Trans.* 212. pp. 299-337, Nov. 13, 1912.)—The author applies his previously-obtained integrals of the equations of propagation of electric disturbances in terms of the electric and magnetic forces tangential to any surface enclosing the sources of the disturbances. The effect produced by an obstacle is represented as a distribution of sources throughout the space occupied by the obstacle, and the solution consists in determining this distribution, or, what the author has found to be the same, the determination of the electric and magnetic forces tangential to the surface. The waves incident on the surface may be represented as the effect of a distribution of Hertzian oscillators. The electric and magnetic current distributions at each point of the surface are the same as if that point were in an infinite plane surface coinciding with the tangent plane to the surface of the obstacle at the point. The three cases of perfectly conducting, perfectly absorbing, and imperfectly conducting obstacles are discussed and their respective asymptotic expressions obtained.

H. H. Ho.

492. *Current-potential Curves of the Oscillating Spark and the Mechanism of Spark Conduction.* S. R. Milner. (*Phil. Mag.* 24. pp. 709-721, Nov., 1912.)—Current-potential curves of the oscillating spark are obtained by the simultaneous magnetic and electric deflection of the cathode-ray pencil in a Braun tube. The primaries of two induction coils are connected in series. The first coil sends a volley of cathode rays through the tube, while the other simultaneously excites the oscillation circuit. Photographs of the curves are reproduced. When the current and the p.d. between the plates of the condenser are combined, the curves are spirals, which show that, as theory demands, the potentials and currents are damped harmonic curves, differing in phase by 90° . The decrement is more nearly uniform than logarithmic,

Curves connecting current with p.d. across the spark-gap are "crosses," showing an undamped p.d. The potential and current curves deduced are shown in the Fig. As the current passes through zero, the p.d. rises rapidly to a "glow" p.d. of 800 volts, and then falls suddenly to an "arc" p.d. of 85 volts, at which it remains while any measurable current is passing. The arc p.d. increases with spark length and decreases slightly with high frequency, but the glow p.d. is independent of both. The theory suggests that the difference between the spark and the arc discharge is to be found in the comparative coolness of the instantaneous anode. It is this that gives rise to the glow p.d. Once the initial ionisation of the gap has taken place under the sparking p.d., the surface of the kathode rises rapidly in temperature under



bombardment of the massive positive ions of low penetrating power and emits corpuscles freely, and thus the p.d. falls to the arc p.d. The corpuscles, however, with their greater penetrating power will distribute their energy over a thicker layer of the anode, which will thus not rise to the same surface temperature as the kathode. On reversal, the new kathode is comparatively cool, and cannot supply corpuscles at the necessary rate. The air in the gap, however, is ionised, and thus the conditions for the glow discharge are present, until the surface of the new kathode has risen in temperature. A number of features of the spark are elucidated by the theory, and photographs supporting the theory are given. Incidentally it is mentioned how the apparatus may be used to determine frequencies as high as 2×10^8 per sec.

T. P. B.

493: *Measurement of Damping in Electrical Oscillation Circuit.* F. Kiebitz. (Deutsch. Phys. Gesell., Verh. 14. 22. pp. 1016-1022, Nov. 80, 1912.)—Bjerknes' method of determining damping involves the assumptions (1) that the influence of the damping on the frequency is negligible; (2) that the resonance curve is used only in the neighbourhood of the resonance point; (3) that the back-working of the secondary on the primary is negligible. With regard to (3) it is very difficult to determine a small coupling, and,

therefore, it is in many cases uncertain whether Bjerknes' formulæ are applicable or not. In the present paper theory is given leading to formulæ which may be employed without the reservations (2) and (8). T. P. B.

494. *Oscillographic Study of the Singing Arc.* J. E. Hoyt. (Phys. Rev. 85. pp. 387-396, Nov., 1912.)—The object of the paper is to discover how the musical note emitted by the arc varies in character as two or more condenser circuits are placed in parallel across the arc. Oscillograph curves are given, showing the currents in the arc and in the condenser circuits. The construction of an acoustic oscillograph is described, which is used to give a record of the note simultaneously with the oscillograms of the currents. In the case of a single shunt circuit, the sound is isochronous with the electrical oscillation, and shows only one harmonic. For more complex shunts it appears that there are harmonics in the note which do not exist in any of the electric circuits. With a complex shunt the note is more likely to correspond to the higher electrical frequency, when the arc is short, but to the lower when the carbons are further apart. T. P. B.

495. *Effect of Magnetic Field on Ionisation Currents.* W. Duane. (Le Radium, 9. pp. 842-847, Oct., 1912.)—A complete account of the experiments described in Abstract No. 1542 (1911), the preliminary results being verified. E. M.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

496. *Electric Conductivity of Diamond.* H. v. Wartenberg. (Phys. Zeitschr. 13. pp. 1128-1126, Nov. 15, 1912.)—As the result of these experiments it is concluded that diamond up to 1850° has at least a specific resistance of 10^6 ohms-cm. and probably a much greater value. E. H. B.

497. *Electric Conductivity of Thin Films of Dielectric.* E. Branly. (Comptes Rendus, 155. pp. 988-989, Nov. 11, 1912.)—With a view to elucidating the action of wireless detectors, the author studies the behaviour of thin films of dielectrics. The substances used are gutta-percha, collodion, mica, celluloid, and paraffin. The thickness of the films varies from 5μ to 25μ . The films are placed between a fixed metallic disc and a movable one, which is pressed against the film with varying pressure. All the films exhibit the same behaviour. They all become conducting at a certain pressure, the current through the film being proportional to the e.m.f. When this conductivity has been established, an electric discharge at a distance reduces suddenly the resistance of the film. The electric state of the film is again stable, the current being proportional to the e.m.f. A suitable mechanical shock restores the resistance of the film to its original value. A small contact gives the same results as the disc contact. The dielectric film between two metallic discs is, at suitable pressures, as sensitive as other wireless detectors, and may be used for quantitative determinations. T. P. B.

498. *Surface Conduction of Electricity.* J. Stock. (Acad. Sci. Cracovie, Bull. 6a. pp. 635-656, June, 1912.)—Measures the conductivity of nitrobenzol and other liquids with and without the addition of quartz sand to increase its surface. Calculates, on the basis of Helmholtz's theory, the thickness of the electric double layer active in electric osmose. It turns out to be about

20 times the diam. of the molecule. The charge per cm^2 of the limiting layer is 1110 e.s. units, which makes the number of monovalent ions per cm^2 2.4×10^{19} , with a distance apart amounting to $6.5 \mu\mu$. This is the same as their mean distance from the wall of the tube. The coefficient of friction between nitrobenzol and glass is $44,000 \text{ gm. cm.}^{-1} \text{ sec.}^{-1}$. E. E. F.

499. *Determination of the International Ampere in Absolute Measure.* E. B. Rosa, N. E. Dorsey, and J. M. Miller. (Bureau of Standards, Bull. 8. pp. 269-398, June 15, 1912. Electrician, 70. pp. 846-847, Feb. 7, 1912. Abstract.)—This paper describes in full the new current balance constructed at the Bureau of Standards [see Abstract No. 74 (1912)]. The type of balance is similar to that used by Rayleigh in 1884, and since employed by Janet, Laporte, and Jonast, at Paris. The electrical system consists of one pair of fixed coils and one moving coil, and with these (on reversal of a current of 1 amp.) the balancing mass is about 6 gm. To reduce the error due to the heating of the fixed coils a system of water cooling was designed to carry away the heat as fast as generated. To protect the moving coil from outside influences it was enclosed in a water-jacket through which water at a constant temperature was passed. To obtain checks upon the work and a final result of greater weight, several pairs of fixed coils have been used, and several different moving coils, with two different radii both in the fixed and in the moving coils. Rayleigh has shown that the ratio of the radii of the coils is the principal term in the constant of the instrument. Very careful measurements were made, therefore, in order to obtain this ratio with high precision. The construction of the balance is described in detail, and the sources of error, e.g., maladjustment, effect of leads, changes in dimensions, errors in measurements of dimensions, and magnetisation of parts are fully considered. The final result is given in two forms: (1) That the e.m.f. of their Weston normal cells at 20°C . was 1.01822 semi-absolute volts [*i.e.* in terms of the international ohm and ampere (10^{-1} C.G.S.)], and (2) the electrochemical equivalent of silver when pure electrolyte is used in a porous pot form of voltameter or a non-septum form, is 1.11804 mgm. per coulomb. F. E. S.

500. *Absolute Measurement of Resistance by Alternating-current Methods.* A. Campbell. (Roy. Soc., Proc. Ser. A. 87. pp. 391-414, Oct. 31, 1912.)—A standard mutual inductance of novel type [see Abstract No. 1571 (1907)] has formed the basis for the determination of the unit of resistance in absolute measure by two different methods in both of which alternating current is used. In the first of these, two-phase alternating currents are used. If M is the mutual induction of the inductometer and R is the standard resistance the alternating p.d. on which is balanced by the induced alternating p.d. on the inductometer, then $R = A\omega M/B$, $A \cos \omega t$ and $B \sin \omega t$ being the instantaneous values of currents in quadrature. A vibration galvanometer tuned to the frequency of the alternator was used as a detector. The mean result of 8 experiments shows that 1 international ohm = 1.0002 ohm (10^{-9} C.G.S.). In the second method the capacity of a condenser is evaluated in terms of a resistance R and a frequency n by Maxwell's commutator method, and in terms of two resistances (R and P) and a calculated mutual inductance M , by Carey Foster's method. The first method gives $b\pi KR = a(1 - \beta)$, where b and a are the ratio arms, K is the capacity of the condenser, and β a small correction depending on the resistances of the galvanometer, battery, etc. The Carey Foster method gives $PKR = M$ (corrections being neglected), and from the two methods we have $P = Mnb/[a(1 - \beta)]$ which

gives P in terms of a mutual inductance and a frequency. Various difficulties having been considered, and especially the variation of capacity due to change of frequency, the final result is given as 1 international ohm $= 1.0002$ ohms (10^{-9} C.G.S.), a value almost identical with that obtained by the two-phase method. The probable error is given as about 1 part in 10,000.

F. E. S.

501. *The Silver Voltmeter.* E. B. Rosa, G. W. Vinal, and A. S. McDaniel. (Electrical World, 80. pp. 1261-1268, Dec. 14, 1912. Elektrotechn. Zeitschr. 84. pp. 232-234, Feb. 27, 1913.)—An historical review of the work done on the silver voltmeter from 1880 to 1908 precedes a description of the authors' investigation at the Bureau of Standards. The results of this investigation are given in 4 papers. In the first two of these the voltmeters are described. Some of the kathodes were of platinum and some of gold, and the capacities varied from 125 c.cm. to 850 c.cm. The types of voltmeters used were: (1) with filter paper, (2) with the porous cup, (3) with a glass cup under the anode, and (4) the siphon form. A difference in the silver deposits of about 40 parts in 100,000 was found between the filter-paper voltmeter and the porous-cup form, the latter giving the lower value. It was found that a silver nitrate solution was contaminated by means of filter-paper and the contaminated solution gives the heavier deposit on electrolysis. All kinds of paper produce the same effect as do also many organic materials. Striation in the deposits could be produced only by adding strong reducing agents to the electrolyte, and since the filter-paper deposits were striated it was evident that cellulose must act as a strong reducing agent. Further experiments led to the conclusion that the reducing action on AgNO_3 solutions takes place through the formation of oxycelluloses, probably decomposing into furfuraldehyde or some of its homologues. Since pure cotton cellulose is a hexopolyose, and not generally considered as yielding furfuraldehyde, careful tests were made which showed it to be present. A pure electrolyte containing 0.001 per cent. of polymerised furfural when electrolysed gave a strongly striated deposit similar to that of the filter-paper voltmeter. The authors have formulated a theory to account for the changes from the crystalline deposits of pure solutions to the non-crystalline and striated deposits of the impure solutions. It appears that the first essential condition for striations is the presence of a colloid that will be deposited on the kathode. The second essential condition is a motion of the liquid over the kathode surface. F. E. S.

502. *Resistance Coils for Alternating-current Work.* H. L. Curtis and F. W. Grover. (Bureau of Standards, Bull. 8. pp. 495-517, Nov. 1, 1912.)—A theoretical discussion is given to show the conditions which must be fulfilled in the construction of resistance coils in order that the phase angle shall be small and the change of resistance with frequency negligible. These principles are applied to the design of coils of different values, and specifications are given for the construction of coils of different denominations from 0.1 to 10,000 ohms.

F. E. S.

503. *Silver Voltmeter.* A. Boltzmann. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1051-1074, June, 1912.)—Experiments were made to compare the relative weights of the silver deposits in voltmeters in which the original kathode surfaces were sometimes clean platinum and sometimes platinum coated with silver. The deposits were from 1 to 8 gm. and those on a clean Pt surface were about 0.1 mgm. heavier than the deposits on a surface

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previously coated with silver. A still heavier deposit was obtained when the area of the clean Pt cathode was reduced by one-half. The author concludes that it is best to make the deposit on a cathode previously coated with silver. Other experiments were made to detect the influence, if any, of the anode liquid; no disturbing influence was found. Further, the mass of the deposit was found to be the same when the voltameter was exposed to bright sunlight as when kept in the dark. F. E. S.

504. Measurement of the Inductances of Resistance Coils. F. W. Grover and H. L. Curtis. (Bureau of Standards, Bull. 8. pp. 455-485, Nov. 1, 1912.)—In this paper is treated the measurement of the "effective inductance" of non-inductive resistance coils for use in alternating-current bridges and in potentiometer circuits where it is desired to know the phase-angle. The latter depends on the inductance and the capacities between the windings and between the various parts of the coil and the earth. The "effective inductance" is that value of inductance which would produce the observed phase-angle. The measurements with coils of low resistance are best made by means of a substitution method, using as a standard of reference a resistance of the same nominal value as the unknown, but such that its inductance may be calculated from its dimensions. Both parallel wires and circles have been used. To obtain small variations of resistance, with negligible change in inductance, wires of equal dimensions but of different conductivities were substituted one for the other. For resistances of 1000 ohms and upwards the capacity of a parallel-wire standard with respect to the earth becomes important. Attention is called to the fact that the usual formula for the capacity of such a standard applies only when the potential of one wire is as much above the earth potential as the other is below it. A method is given for adjusting the potentials of the bridge to their correct values, and this, having been accomplished, the substitution method gives accurate results with resistances at least as high as 10,000 ohms. Two methods are given for the measurement of the effective inductances of coils in those cases where it is impracticable to construct primary standards but these are not so precise. F. E. S.

505. The Mutual Inductance of Two Coaxial Circular Currents. H. Nagaoka. (Phys. Soc., Proc. 25. pp. 81-84; Discussion, p. 84, Dec., 1912.)—Methods are given for the rapid calculation of the mutual inductance of two coaxial circular currents. Maxwell's first formula is converted into theta-functions and then expanded in a Jacobian q series. The logarithmic values of this series have been tabulated in a previous paper by the author. When the circles are near to one another a series for M is given in terms of q_1 , where q_1 is the complement of q . In this paper Maxwell's second formula is treated in a similar way. A table of the values of these series formulae, computed by Tishima to seven decimal figures, is given. The chief advantages of this table are that nearly all practical cases are included within a short range of the argument, and the calculation is simple, as the numbers in the difference columns are small. By the help of these tables and series the mutual inductance between two coaxial currents can be easily computed to a high degree of accuracy. A. R.

506. Resistance Measurements of High Precision. F. E. Smith. (Phil. Mag. 24. pp. 541-569, Oct., 1912. From the National Physical Laboratory.)—Certain new bridge methods of measuring with high precision the resistance
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of a platinum thermometer, or similar resistance, are described. The sources of error due to the heating effect of the current and the heating effect in the bridge arms are considered, and various arrangements of the resistance measuring apparatus designed to secure accuracy are fully discussed.

J. J. S.

507. Four-terminal Conductor and the Thomson Bridge. F. Wenner. (Bureau of Standards, Bult. 8, pp. 559-610, Nov. 1, 1912.)—In low-resistance standards capable of carrying large currents, the surfaces of the contacts through which the current enters and leaves must be large. In many cases the resistance depends, to some extent, on the manner in which the current leads are attached. In alternating-current measurements it is also necessary to know the inductance. The present paper points out the conditions which must be fulfilled in order that the resistance may be definite, or both the resistance and inductance be definite. The design of low-resistance standards is discussed, and the theory of the Thomson bridge using linear four-terminal conductors is given. [See also Searle, Abstract No. 475 B (1910).]

F. E. S.

508. Hall-effect in Metals at Low Temperatures. H. Alterthum. (Ann. d. Physik, 89. 5, pp. 988-960, Dec. 5, 1912.)—An experimental and theoretical research of which the chief results may be summarised as follows:—(1) In extension of previous data the Hall-effect was investigated at various temperatures down to that of liquid hydrogen. The temperatures actually used were (a) room temperature 291° K., (b) a mixture of solid CO_2 and ether at 194° K., (c) liquid air 88° K., and (d) liquid hydrogen at 20° K. (2) The curves for the Hall-effect and temperature have a regular form; Cu, Cd, Sb, Au show maxima, Al and Pt minima. (3) The ferromagnetic bodies Fe and Ni decrease to the temperature of liquid air, and then assume a constant value. (4) The previous attempts to bring the Hall-effect into agreement with electron theory by explaining it as due to the action of the field on free electrons could not account successfully for the difference of the signs. (5) Also at very low temperatures, since the conductivity (and therefore the speed of the electrons) there increased, the Hall-effect should have increased, which is not the case. (6) The present experimental data with their maxima and minima point rather to the existence of some complicated relations lying at the root of the Hall-effect. (7) At the absolute zero the relations are essentially simplified. The endeavour is made to bring the Hall-effect at absolute zero into relation with diamagnetism. (8) The curves with maxima belong to diamagnetic metals, those with minima to paramagnetic ones. (9) This relation held for Cu, Au, and Ag, whose Hall-effects have the negative sign. (10) No such relation could be found for Zn, Cd, Sb, Te, and Pb, nor for the magnetic metals (except Fe and Co), whose Hall-effects have the positive sign. (11) It is also found that the diamagnetic susceptibilities of these metals are not independent of the temperature. [See Abstract No. 448 (1910).]

E. H. B.

509. Three-plate Condenser and Dielectric Constants of Solid Bodies. E. Grüneisen and E. Giebe. (Phys. Zeitschr. 18, pp. 1097-1101; Discussion, p. 1101, Nov. 15, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—The determination of the dielectric constant of a solid body by placing a plate of the substance between the two plates of a condenser can only be made accurately if special precautions are taken. The "edge" correction and the capacity of the condenser with respect to the

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earth must both be taken into consideration. A three-plate condenser in which the two outer plates are earthed is to be preferred to a two-plate condenser because the capacity is independent of the surroundings, and the "edge" correction is proportionately smaller. A formula is given for the calculation of the capacity of a three-plate condenser, and this formula is verified by experiment.

T. P. B.

510. Volta-effect. F. Sanford. (Phys. Rev. 35. pp. 484-489, Dec., 1912.)—Finds by experiments that the Volta-effect is not due to any electrolytic action between the opposed metals, but different metals when in contact with the earth or with the inside of the same hollow conductor may be at different potentials relative to each other.

E. H. B.

511. Thermo-electric Properties of the Iron-Nickel-Carbon System. E. L. Dupuy and A. Portevin. (Comptes Rendus, 155. pp. 1082-1085, Nov. 25, 1912.)—The authors have determined the thermal e.m.f. against lead of alloys containing 0.07 to 1.05 % carbon and 0 to 80 % Ni, the residue being iron except for impurities which never exceeded 0.25 %. Measurements were made between -78.5° and 0° C. and 0° and 100° C. on samples as made, after annealing, and after hardening. The results, plotted in the form of concentration-e.m.f. curves show a minimum at the martensite-austenite change-point. It is suggested to use the method as one to control the results of chemical analysis.

F. C. A. H. L.

512. Construction and Constants of a Rectangular Galvanometer. A. Ferguson. (Phil. Mag. 24. pp. 788-804, Nov., 1912.)—The field at any point in the plane of a rectangular coil carrying a current i can be expressed in the form $F = i(1/p_1 + 1/p_2 + 1/p_3 + 1/p_4)$, where p_1, p_2 , etc., are the lengths of certain perpendiculars. If i is measured by means of a current balance, F can be obtained in terms of it and $\Sigma(1/p)$. The author then enters into a mathematical discussion and shows that for a rectangular coil of given length of wire the square is the least advantageous form but is better than the circle as regards field intensity, at its centre of symmetry. He then shows that, for a rectangular single-layer coil of dimensions, $c = 21$ cm. and $d = 80$ cm., and with breadth of winding of 1 cm., the field at the centre of the coil is $4i/cd \cdot \sqrt{(c^2 + d^2)}$, the error introduced in neglecting the breadth being of the order of 1 part in 10,000. He points out that an important error may arise through irregularities in the winding of the turns and shows how to calculate the errors due to slight deviation from trueness in the side of a square. The error due to curvature at the corners is negligible. To test the galvanometer he measures H , and obtains results which are in good agreement with those secured with the aid of a Helmholtz galvanometer having cylindrical coils.

W. C. S. P.

ALTERNATING CURRENTS AND MAGNETISM.

513. Multi-lamellar Magnetic Screens. W. Esmarch. (Ann. d. Physik, 89. 6. pp. 1540-1552, Dec. 23, 1912.)—The galvanometer of Du Bois and Rubens is provided with a triple shield, and that used by Nichols and Williams with a quadruple screen [but see Abstract No. 291 (1909)]. The author describes experiments on the effect of multiple screens made from alternate layers of iron wire and cardboard. The method of testing was by means of two opposed current circuits round a needle, one circuit within and

the other outside the screen. The wires employed to form the screens were of Russian and Swedish iron with a permeability between 100 and 116. The results are given in the form of curves and tables. These show that the screening increases with the number of layers, but very slowly after a certain number of layers is reached. It is advantageous to use cardboard of the same thickness as the wire employed, and the permeability of the iron wire has a great influence on the amount of screening obtained. In some cases over 60 layers of iron wire were employed. G. E. A.

514. Theoretical Contribution to Methods of Measuring the Hall-effect. F. Koláček. (Ann. d. Physik, 89. 6. pp. 1491-1589, Dec. 28, 1912.)—A thin rectangular plate of cast bismuth has two thick copper wires connected to its short sides, and a single thin copper wire (Hall electrode) to the middle of one of the long sides, whilst the opposite long side has a pair of electrodes at equal distances from the midpoint of that side. The pair of points is connected through a rheostat or resistance box, and the galvanometer is placed between the rheostat and the single electrode. The galvanometer deflection due to the Hall-effect depends on the distance of the pair of electrodes from the middle of the side, and is reduced by one-half when the electrodes are at the ends of the long side. This presents a mathematical problem in conduction with which the rest of the paper is concerned. G. E. A.

515. Thermomagnetic Study of Steel. S. W. J. Smith. (Phys. Soc., Proc. 25. pp. 77-81, Dec., 1912.)—Use is made of the fact that there is, for simple ferromagnetic substances, a field for which the permeability variation with temperature is comparatively small except in the neighbourhood of the critical temperature. In such fields there is a very clearly marked peak in the permeability-temperature curve. This peak is exhibited by the carbide of iron (cementite) which exists in annealed carbon steels, and in a particular steel containing 0.85 per cent. of carbon there was a sharply marked maximum of permeability at 210°C. It is considered possible to determine the percentage of carbon in a given steel by means of this thermomagnetic property. G. E. A.

516. Changes in Iron and Steel at High Temperatures. K. Honda and H. Takagi. (Mathematico-Physical Soc., Tōkyō, Proc. 6. 20. pp. 294-306, Oct., 1912.)—It has been determined metallographically that α iron, the strongly magnetic form, is converted into β iron, only weakly magnetic, at 770°C. and into the γ , or most feebly magnetic, form at 890°C., and that similar changes occur in mild steels. Unlike the processes of melting and boiling, these changes do not take place at one definite temperature but within a certain definite temperature-interval. Magnetic tests have also shown that γ iron is converted into δ iron at 1280°C. Although a change in state necessitates alteration in one or more properties of a body it does not follow that the whole of the properties are affected by the change. Experiments in which magnetic permeability, temperature, and time have been observed simultaneously, have been carried out on Kahlbaum's pure iron, steels containing from 0.14 to 1.5 % carbon and on a steel containing 5 % tungsten and 0.6 % carbon. The results show that the β - α or α - β change occurs over a small interval of temperature which increases with increase of carbon. The evolution of heat during the β - α or γ - α change cannot be observed in the case of steels. Eutectic separation of iron from solid solution is accompanied by a much larger evolution of heat and by a VOL. XVI.—A.—1918.

discontinuity in the increase of magnetic permeability. The temperature of the eutectic change is $80-40^{\circ}$ higher on heating than cooling. Recalescence results from the separation of iron from the solid solution and not from the $\beta-a$ or $\gamma-a$ change in the iron. F. C. A. H. L.

517. Magnetisation of Heusler Alloys as a Function of the Temperature. P. W. Gumaer. (Phys. Rev. 85. pp. 288-305, Oct., 1912.)—The ballistic method employed by Weiss and Stiffler was used to determine the saturation value of the magnetisation intensity for two ellipsoids containing about 62 per cent. of copper. A molecular theory of magnetism is developed, from which the variation of specific intensity of magnetisation with temperature could be expressed. The experimental and theoretical curves agree above 200°C. , and the critical temperature was 310°C. Chilling the specimens from near the melting-point causes the experimental curve to follow the theoretical curve to a lower temperature than before, and the molecular field was found to be of the same order of magnitude as that for nickel. The fundamental equation on which the theory is based has been derived mathematically, thereby making the former analogy to the gas theory unnecessary. G. E. A.

518. Coefficient of Magnetisation of Water and Oxygen. P. Weiss and A. Piccard. (Comptes Rendus, 155. pp. 1284-1287, Dec. 9, 1912.)—The magnetisation of water was measured by Quincke's method. First the magnetisation of a concentrated solution of chloride of manganese was measured and subsequently compared with water by noting the attraction or repulsion of an electromagnet on a quartz tube filled successively with hydrogen, water, and the solution. Susceptibility per unit mass $\chi = -0.7198 \times 10^{-6}$ at 20° with a temperature coefficient $\alpha = +0.00018$ in this neighbourhood. The susceptibility of oxygen was measured by comparing the height of water in a magnetic field under oxygen with that under hydrogen. For dry oxygen at 760 mm. and 20° :—Susceptibility per unit vol $K = +0.14078 \times 10^{-6}$; for air under same conditions $K = +0.02941 \times 10^{-6}$; oxygen per unit mass $\chi = +1.0568 \times 10^{-4}$. Considering the two atoms of oxygen as a rigid system as the specific heat requires, on calculating the magnetic moment of the molecule we find $\mu = 7.007$ magnetons per atom; the magneton 1128.5 being the common measure of the atomic moments of iron and nickel observed in liquid hydrogen. Considering the molecule as a non-rigid system $\mu = 9.90$ per atom. J. M.

519. Constitution of Water. A. Piccard. (Comptes Rendus, 155. pp. 1497-1499, Dec. 28, 1912.)—The author has observed that the susceptibility of water is 0.75 % greater at 100° than at 0° [see preceding Abstract]. Since generally the susceptibility only changes with change of state, he assumes that water consists of two substances in equilibrium, the less dense having the density of solid ice. From density measurements the percentage of pure water and ice are calculated at different temperatures. The decrease in susceptibility for the temperature interval $100^{\circ}-0^{\circ}$ being due to the formation of a definite amount of ice, the sudden decrease on solidification can be calculated. This is 1.9 %; observed, 2.4 %. The agreement between the curves for the composition of water from the volumetric and from the magnetic properties is very close. J. M.

520. Magnetic Effect of Oceans. A. Berget. (Comptes Rendus, 155. pp. 1198-1200, Dec. 9, 1912.)—Reference is first made to Wilde's VOL. XVI.—A.—1918.

Magnetarium, described in 1890, in which the earth's magnetism was represented as composed of two actions: that of the central nucleus and that of the crust. This is considered in relation with Lippmann's theory of the distribution of matter at the earth's surface, and a diagram given suggesting a difference in level of the nucleus material, which is supposed to be strongly magnetic. The portions in excess are arranged under the ocean areas, and would have some such effect as the metallic plates in Wilde's apparatus. C. P. B.

521. Magnetic Disturbances, Earth Currents, and Solar Eruptions. J. Bosler. (Journ. de Physique, 2. Ser. 5. pp. 877-891, Nov., 1912. Paper read before the Soc. franç. de Physique, May 8, 1912.)—Summarising the results of an examination of the Greenwich magnetic curves it is shown that as the first movements of a magnetic storm are generally in the same direction with regard to the local meridian, the direct cause of the perturbations must be terrestrial, and it will move with the earth. It has usually been noticed that magnetic perturbations have been synchronous with large variations of the intensity of earth currents. Plottings of the current and magnetic field variations from the records of Saint-Maur and Greenwich indicate a concentration of these factors in two definite orientations, approximately differing by 90° ; this suggests some similarity of effect to that exerted by a current in a wire on a magnet pole brought near the circuit. Moreover the general results of most observers indicate that the magnetic disturbances are more related to the solar features exhibiting rapid changes, rather than to any particular large spot or prominence which may be visible at the time. The magnet disturbances would thus be regarded merely as the variations of earth currents always present, but only of special notice when rendered of unusual magnitude by the influence of solar induction. C. P. B.

RADIOLOGY AND ELECTROPHYSIOLOGY.

522. Spark Inductors and Röntgen Tubes. F. Dessauer. (Phys. Zeitschr. 18. pp. 1101-1104; Discussion, pp. 1104-1105, Nov. 15, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—The method of breaking the primary circuit by means of melting a metallic wire so that a large current acts for a small period of time is further described [see Abstract No. 272 (1910)]. It is shown that in about $1/25$ sec. after closing the primary circuit both the current and the magnetic field attain the required maximum, and that in a little over $1/1000$ sec. later the primary current of more than 250 amps. is reduced to zero, and this without having a condenser in the circuit. The use of the apparatus for studying the heart's action, etc., is discussed. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

523. Chemically Active Modification of Hydrogen. I. Langmuir. (Amer. Chem. Soc., Journ. 84. pp. 1810-1825, Oct., 1912.)—When a tungsten wire is heated at 1802-2500° K. in hydrogen at very low pressure (0.001-0.002 mm.), the hydrogen slowly disappears. With nitrogen or CO such disappearance never occurs below about 2200° K., and seems to be an electrical effect, whilst with hydrogen it appears to be purely thermal. There is a distinct fatigue effect, but the substitution of fresh wire does not restore the action. The hydrogen is not absorbed by the wire but is deposited on the glass, especially where the latter is cooled by liquid air. If the wire is allowed to cool and the liquid air then removed, ordinary hydrogen is liberated which will not re-condense when the liquid air is replaced. If this gas is pumped out and oxygen admitted, the oxygen will disappear and in its place a small quantity of hydrogen will appear. With platinum and especially with palladium wires these effects are much more marked. These phenomena are not due to the presence of finely-divided metal on the surface of the glass. When phosphorus is present on the bulb and hydrogen is introduced and the wire heated, the hydrogen disappears and hydrogen phosphide is formed. The theory is advanced that the hydrogen dissolves in the material of the wire in the atomic condition, and that some of these atoms, leaving the wire, do not meet other atoms (owing to the low pressure) but diffuse into the tube cooled by liquid air or become adsorbed by the glass, and thus remain in the atomic condition and retain all the chemical activity of the atoms. T. H. P.

524. Influence of Radium Radiations on Glass and certain Minerals. S. Meyer and K. Przibram. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1418-1418, July, 1912. Communication from the Inst. f. Radiumforschung.)—Fluorspar on exposure to β -rays was found to turn to a blue colour and to possess the property of being thermo-luminescent at a temperature as low as 60° C. Protracted heating reduced the fluorspar to normal condition. As kuuzite shows similar effects the authors consider that all thermo-luminescent bodies have their temperature of thermo-luminescence reduced by exposure to β -rays. Different glasses exposed to β -rays either assume a brown colour or a violet colour. Some bottles of radium solution were coloured brown where the liquid was in contact with the glass and blue above the surface, the latter colouration being probably due to the radium emanation. Brown-coloured glass heated carefully thermo-luminesces with a greenish light like that due to X-rays, and afterwards becomes violet. With further heating up to the softening point the violet colour gradually disappears with no further luminescence. By exposing either brown-coloured glasses or uncoloured glasses of the same type to ultra-violet radiation a pale yellow colour is the result. Violet-coloured glasses (due to β -radiation) are, however, little influenced by ultra-violet light. The authors do not consider that the theory that the colourations are due to solid solutions of Mn, Fe, etc., is sufficient to account for all the results, although no definite theory is put forward. Some interesting results on the photoelectric effects of powdered substances after exposure to β - and γ -rays were observed. Fluorspar which has become fatigued rapidly recovers a strong photoelectric activity after an

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hour's exposure to the β - and γ -rays, whereas it does not recover so rapidly when left alone in the dark. Further, the recovered effect is stronger than the natural effect, but with lasting exposures its photoelectric fatigue proceeds quicker. Similar results were obtained with kunzite. Glass was also found to be photoelectric after exposure to β - and γ -rays, the effect falling off only slowly with continued exposure to the ultra-violet light. E. M.

525. Size of the Molecule of Metals in Solid Solutions. M. Padoa and F. Bovini. (Accad. Lincei, Atti, 21. pp. 708-718, Nov. 17, 1912.)—Experimenting with alloys of Sn-Cd-Bi, the authors have compared the compositions of the original molten alloys, of crystals deposited therefrom during cooling, and of the residual mother-liquor, showing that the concentration of Cd in Sn in the solid state approximates closely to that in the liquid state, so that Cd in the solid state is also monatomic. W. H. S.

526. The Chemical Method for the Study of Alloys. A. Portevin. (Rev. de Métallurgie, 9. pp. 884-890, Nov., 1912.)—This is one of the oldest methods for the study of the constitution of alloys, and consists in isolating one constituent by solution of the others in suitable reagents and subsequently analysing the residue. Hence the method has also been called the "method of examination of residues." After dealing with the common objections to the method such as lack of uniformity of composition of the reagent chosen, etc., the author points out two further difficulties, viz. (1) the entrapment of liquid in the primary crystals formed during solidification, and (2) the envelopment of the primary crystals by a definite compound formed by a reaction between the crystals and the surrounding medium subsequent to the beginning of crystallisation. It is therefore advisable to make a preliminary micrographic examination of alloys intended for study by this method. F. C. A. H. L.

527. Platinum-Aluminium Alloys. M. Chouriguine. (Rev. de Métallurgie, 9. pp. 874-888, Nov., 1912.)—The constitution, structure, and properties of a complete series of these alloys have been studied. To prevent oxidation the metals were melted under lithium chloride in a magnesia crucible heated in an electric furnace. The metals combine with the liberation of a considerable quantity of heat, and on account of their differences in density there is a tendency towards liquation. The thermal diagram shows a eutectic point at 9 % Pt and 689° C., and three discontinuities between this point and the solidification point of Pt. It appears probable that the compounds PtAl₃ and PtAl₂ are formed. On dissolving alloys containing between 10 and 70 % Pt in 5 % hydrochloric acid a crystalline residue of the composition corresponding to PtAl₃ is obtained. Microscopic analysis confirms these views. Between 70 and 90 % Pt the alloys appear golden-yellow under the microscope, and above 70 % Pt a new microconstituent makes its appearance. Solution of these alloys yields a residue containing 90 % Pt, which does not correspond to any simple formula. F. C. A. H. L.

528. Copper-Zinc-Nickel Alloys. L. Guillet. (Comptes Rendus, 155. pp. 1512-1514, Dec. 28, 1912.)—The author has resumed his work on the substitution of zinc in brasses by other metals [Abstract No. 1819 (1906)], and finds that the coefficient of equivalence of nickel lies between -1.1 and -1.4. An alloy containing 56.7 % Cu, 89.7 % Zn, and 8.4 % Ni has a micrographic value equal to 60 % Cu, and a calculated fictitious value equal to 60.4 % Cu.

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Compared with those of brasses containing 60 and 56·7 % of copper respectively its mechanical properties are as follows :—

	Nickel Alloy.	60 per Cent. Cu Brass.	56·7 per Cent. Cu Brass.
Tensile strength, kg. per sq. mm.	47·2	35	40
Yield	15·8	12	12
Elongation, " " " " "	42·0	80	10
Reduction of area, per cent.....	51·7	80	15
Shock test on notched bar, ρ	18	10	4
Ball hardness, Δ	97	70	85

Therefore addition of nickel to certain alloys of copper and zinc not only increases the copper-value of the alloy, but at the same time effects a considerable allround improvement in mechanical properties.

F. C. A. H. L.

529. Notes on Ruff's Carbon-Iron Equilibrium Diagram. H. M. Howe. (Amer. Inst. Mining Engin., Bull. No. 71. pp. 1181-1225, Nov., 1912.)—The author discusses at some length the conclusions arrived at by Ruff [see Abstracts Nos. 1406, 1619 (1911)] with regard to the iron-carbon system. Further experiments by the author and others show that graphitisation of cementite takes place at temperatures much lower than Ruff's limiting temperatures. A simpler theory is put forward to the effect that the true eutectic temperature is the governing one; that such undercoolings as occur are undercoolings below, and such recalescences as occur are attempts to reach, the true eutectic temperature.

F. C. A. H. L.

530. Notes on Titanium and its Cleansing Effect on Cast Iron. B. Stoughton. (Amer. Inst. Mining Engin., Bull. No. 71. pp. 1245-1275, Nov., 1912.)—The history, occurrence, physical and chemical properties, and manufacture of titanium are briefly described. On a commercial scale the manufacture of pure titanium is not possible, but by smelting titaniferous iron ore with carbon in an electric furnace ferro-titanium containing up to 15 % Ti can be prepared, while iron alloys containing up to 25 % Ti can be prepared by the "Thermit" method. Experiments made on cast iron showed that addition of ferro-titanium to the cupola had no improving influence, but by correct addition to the ladle the transverse strength can be increased by from 80 to 50 %. The max. effect appears to be obtained with about 0·10 % Ti.

F. C. A. H. L.

531. The Relation of Osmotic Pressure to Temperature. W. F. Magie. (Phys. Rev. 85. pp. 272-275, Oct., 1912.)—The relation of osmotic pressure to temperature may be expressed by the formula $p = a\theta(\log \theta - 1) + b\theta + c$, in which b and c are quantities which are functions of the concentration of the solution, but are independent of the temperature θ . In this formula $-a\theta + c = l$, the heat of dilution of the solution. In the case of aqueous solutions of sodium chloride in water, values calculated by means of this formula with the help of experimental data for ordinary temperatures, agree with those obtained by Kahlenberg for the boiling-point. This is regarded as a satisfactory confirmation of the formula, and especially of the view that the quantity a is independent of the temperature.

T. M. L.

532. Nature of Electrical Colloid Synthesis. C. Benedicks. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. 7. pp. 1-81, 1912.)—The object of the present investigation was to decide whether the formation of colloids by Svedberg's and Bredig's methods is an electrical or thermal phenomenon. Examination of the surfaces of the electrodes of different metals, when an arc was made for a very short time—in some cases only one spark was passed—by Svedberg's method, showed that the surface was covered by a number of craters, which could have been formed by the local melting of the electrode; the surface tension then draws the fused metals outwards and forms a crater. It was found possible to imitate the appearance of the electrodes by blowing a gentle stream of hot air through a narrow tube against a surface of asphalt or of paraffin wax, thus supporting the idea that the phenomena observed are thermal. It would follow that the disintegration of the electrodes, with the formation of a colloidal solution, is due to the liquid streaming against the molten metal after the cessation of the arc and breaking it up into globules. The colloidal particles should therefore consist of small spheres, and the microscopic examination of a deposit which had settled out of a particularly stable solution of colloidal iron in the course of a year confirmed this, none of the particles having a diam. greater than $5\ \mu$. Similar results were obtained with colloidal particles of brass, bismuth, and lead. The formation of metal colloids being a thermal phenomenon, it follows that the amount of disintegration of the various metals will depend (1) on their latent heat of fusion, and (2) on their conductivity towards heat. The order in which the metals have been arranged by Svedberg, with respect to the amount of disintegration, agrees with this. T. S. P.

533. Iron-Carbon System. O. Ruff. (Zeitschr. Elektrochem. 18. pp. 761-764, Sept. 1, 1912.)—The author criticises Smits's discussion [Abstract No. 1468 (1912)] of his work on the iron-carbon system [Abstract No. 407 (1912)]. Generally speaking, the results of the two workers are in good agreement but the author points out that Smits's thermodynamical conclusions as to the meaning of the line BDHY [Abstract No. 407 (1912)] are quite erroneous. F. C. A. H. L.

534. Notes on the Metallography of Alloys. W. Campbell. (Amer. Inst. Mining Engin., Bull. 72. pp. 1881-1400, Dec., 1912.)—The author describes some points concerning the constitution of alloys of lead-antimony-tin, of tin-antimony-copper, and alloys with a zinc base used as bearing metals. Tables are given showing the compositions of alloys used in practice, and their structures are illustrated by some excellent photomicrographs. F. C. A. H. L.

535. Microstructure of Iron and Steel. W. Campbell. (Amer. Inst. Mining Engin., Bull. 72. pp. 1857-1880, Dec., 1912.)—The importance of metallography to the engineer lies in the possibility of identifying certain microstructures with certain mechanical properties, and with this object the author has set forth the main features of the structures of wrought irons, mild, medium, rail, high-carbon, and alloy steels. Typical micrographs of good and faulty materials illustrate the paper. F. C. A. H. L.

536. Viscosity and Fluidity. E. C. Bingham. (Phys. Rev. 85. pp. 407-488, Dec., 1912, and 1. (2nd Series) pp. 96-128, Feb., 1918.)—A summary of the results hitherto obtained [compare Abstracts Nos. 716 and 1748 (1911), 104 (1912)]. T. S. P.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1913.

GENERAL PHYSICS.

537. *Exponential Computer*. L. Ross. (Eng. News, 69. pp. 866-867, Feb. 20, 1918.)—An exponential computer has recently been devised by the author, which consists of a straight-line chart and a straight-edge, or, better, a fine hair-line drawn on a strip of transparent celluloid. This computer multiplies and divides, like an ordinary slide-rule, but in addition it gives at one setting any power, from 0 to infinity, or any root of any number; it will also, at one setting, multiply any number by any root or power of any other number. Trigonometric or any other special functions can be handled by labelling one line on the chart with a scale of those functions. Expressed algebraically, the computer will give at one setting the value of any unknown in the equation $n = mb^p$, or with two settings the value of any unknown in the equation $x = m^p b^p$. The computer is in the form of a rectangle, of which the left and right edges, labelled $m = \text{multiplier}$ and $b = \text{base}$ respectively, carry logarithmic scales, and they are drawn any convenient distance (L) apart. The vertical lines are drawn at distances from the left represented by $Lp/(p+1)$, where p is the power or exponent, indicated at the bottom. The base scale at the upper right corner is extended by folding it over the top marginal line. Diagonal lines are drawn from the bottom right-hand corner of the rectangle to intersect the left-hand side at the points corresponding to the values shown for m . It is easy to show that any straight line across the diagram cuts the vertical p -line at the diagonal $n = mb^p$. Hence, since the position of such a line is determined by two points, the third point, on the left (m) or right (b) scales, or at the intersection of a diagonal (n) with a vertical (p) line, will give the value of the unknown. The extended base (at the top, for $b = 18$ to $b = 10,000$) can only be used with $m = 1$. For any other value of m , first find b^p , then multiply this by m , using the $p = 1$ line for this last multiplication. A. W.

538. *Micromanometer*. A. Henry. (Comptes Rendus, 155. pp. 1078-1080, Nov. 25, 1912.)—The apparatus consists essentially of two cylindrical reservoirs of diam. 4.5 cm., connected by a horizontal tube at the bottom.

The liquid used is carbon tetrachloride, which is not acted on by air and is not inflammable ; moreover its viscosity and surface tension are both small. A small air-bubble in the middle of the horizontal tube separates the liquid into two portions. The apparatus is extremely sensitive and will easily show a movement of the index bubble for a pressure variation of $1/200$ mm. of water. Owing to surface-tension effects there was a slight variation of zero after the bubble had undergone large displacements, but the error due to this would not be as much as 1 per cent. A bubble about 1 cm. long seems to be the most suitable. Various uses are suggested for the manometer.

A. W.

539. Measurement of Gas Densities at High Pressures. A. Occhialini. (N. Cimento, 4. Ser. 6. pp. 426-441, Dec., 1912.)—An apparatus is described for the measurement of gas densities at high pressures, based on the theory, first enunciated by Gale, that if a small volume v of compressed gas is allowed to expand into a receiver having a large volume V , in such a way that the final pressure is slightly above that of the atmosphere, and may be measured, then the mass of the gas originally occupying volume v may be readily determined. Thus, if h is the initial pressure in V , and t the temperature, the total mass before expansion is given by $m + Vh/76(1 + \alpha t)$, and after expansion by $(V + v)H/76(1 + \alpha t)$, whence

$$m = (V + v)H/76(1 + \alpha t) - Vh/76(1 + \alpha t),$$

and hence, dividing by v , the density is calculated. The apparatus consists essentially of a steel compression chamber, the capacity of which may conveniently be from 8 to 10 cm.³, an expansion chamber of glass, of about 900 cm.³ capacity, and a manometer.

W. H. St.

540. Theory of Elasticity. H. Lorenz. (Phys. Zeitschr. 14. pp. 71-74, Jan. 15, 1913.)—The theory of elasticity gives for the displacements ξ , η , ζ of a material point under stress three partial differential equations of the second order, whose rigid integration has only been accomplished in isolated cases. W. Ritz gave approximate solutions from a series of functions of the co-ordinates F_1F_2 ; $\Phi_1\Phi_2$; $\Psi_1\Psi_2$, which fulfil the limiting conditions, the scheme being $\xi = a_1F_1 + a_2F_2 + \dots$; $\eta = b_1\Phi_1 + b_2\Phi_2 + \dots$; $\zeta = c_1\Psi_1 + c_2\Psi_2 + \dots$, where $a_1a_2 \dots b_1b_2 \dots c_1c_2$ are statically indeterminate. If the internal work L_i and the external work L_e is calculated in this manner, their equality yields an equation of condition which connects the coefficients a , b , c . The author illustrates the process by applying it to the case of a beam fixed at one end and carrying a weight suspended from the other. He determines the coefficients $a_1, a_2 \dots$ in such a manner that $L_i - 2L_e$ acquires a singular value in the case of elastic equilibrium. This was also arrived at by Ritz on variation considerations. It appears as a consequence of Castigliano's theorem concerning the work done in changing the shape of elastic systems.

E. E. F.

541. Report on Shock Tests. G. Charpy. (Rev. de Métallurgie, 9. pp. 1015-1025, Dec., 1912.)—In order to emphasise the importance of shock tests it is necessary to define the conditions under which the results of two distinct tests are comparable, and the extent to which the numerical results define the qualities determining the practical value of the materials. With regard to the conditions necessary to ensure comparability of two shock tests it is necessary to consider separately the shape and dimensions of the

test bar, the methods of calculating the results, and the apparatus and method of measurement employed. For small differences in size the resilience (specific work per cm.² of the section at the point of fracture) of geometrically similar bars is practically constant for the same material. Independent tests by Bartel, Ehrensberger, and Charpy on 80 × 80-mm. and 10 × 10-mm. bars have shown that the resilience is always smaller on the small bars than on the large ones, and that the difference is always greater on tough materials than fragile materials. Unfortunately the conditions are not so simple in the case of shock-bending tests to rupture as in the case when deformation only is produced. There are two distinct effects in the former case: first, the work causing the general deformation, which is proportional to the cube of the linear dimensions; and secondly, the work absorbed in separating the two parts of the bar, which should be proportional to a power of the dimensions in the neighbourhood of the square. With regard to the machines used, it is recommended that a method of verifying the graduations should first be devised. Further research is necessary to settle all these points, and a collection of observations is requested giving the following information: Shape, nature, and use of the part; nature and treatment of the metal used in its manufacture; work done, compared with similar parts; circumstances under which breakage or deformation has been produced; sketch indicating the path of the fracture and the positions of the specimens taken, and a statement of the various tests made on the material as delivered during the process of manufacture and after treatment subsequent to the fracture, together with the conclusions drawn particularly from shock-bending tests on notched bars. An example of such a report is appended to the paper.

F. C. A. H. L.

542. Relation of Static Strength to Fatigue Strength under Fluctuations of Load. P. Ludwik. (Zeitschr. Vereines Deutsch. Ing. 57. pp. 209–218, Feb. 8, 1918.)—Every permanent set depends on the internal friction along two systems of cleavage planes. Tests show that the ratio $\lambda : P$ of set to load increases, variously for different metals, with the initial set. Similarly, λ/P decreases with increasing speed of deformation, so that a series of load-deformation curves is obtained for various speeds, the lowest being that for zero velocity, *i.e.* infinite duration of test. If a load P which is $< U$, the max. load attained on the lowest (or static) curve, be applied to a piece, then the strain increases at first rapidly, then more slowly, finally becoming stationary. The author's tests on tin wires show that if $P > U$, the strain grows steadily to the value corresponding to U on the static curve, and then more slowly to failure. When load is applied at a steady rate up to P and is removed, the curve falls more or less steeply, according to the rapidity of unloading, till it intersects the static curve at a load P_0 , when it falls to zero along the load ordinate. On being reloaded at the same rate the material yields when the load P_0 is again attained. Thus when P is repeatedly applied, each fluctuation gives rise to two sets in addition to the initial set, which tend to zero, if $P < U$, in such a way that the total set is equal to that for the load P on the static curve. If $P > U$, the cumulative sets decrease until the total reaches the set for max. load on the static curve, when they start increasing till failure occurs. With metals which show a sharply defined yield-point a period of 4 days' rest between unloading and reloading raises the new yield-point by as much as 18 % above the initial load, showing that the self-hardening after overstraining is a time-function. The author finds, however, that this effect is absent with metals such as copper and zinc,

which show smooth stress-strain curves ; these should therefore conform to the above theory and have a strength under fluctuating stress equal to the static strength. Owing to dynamic effects, to eccentric loading and to the well-known effect of irregularities in the surface of specimens and of want of homogeneity, the dynamic strength was expected to be less than the static, but not by 80 % as has been found. The author finds that $\frac{1}{2}$ -mm. soft well-annealed electrolytic-copper wires 1 m. long fail after 5 mins. under 4958 gm. load, after 2 hours under 4785 gm., and 90 hours under 4500 gm. Two such wires loaded with 8950 gm. failed after $14\frac{1}{2}$ months at an ultimate strain of 20 %, whilst 8500 gm. had failed to cause fracture after 2 years, and the strain was then only 11 %. Thus the discrepancy between the dynamic strength and the static strength as determined in an ordinary tensile test is due to the true static strength being over 20 % less. E. J. S.

543. *Shock Tests on Notched Bars.* C. Fremont. (Rev. de Métallurgie, 9, pp. 1168-1166, Dec., 1912.)—The report to the 5th International Congress of the Assoc. for Testing Materials is criticised as regards the choice of apparatus, the dimensions of the test-bars, the shape of the notch and certain conditions of the test. It is suggested that the height of fall should be at least 4 m., or the impact velocity should be correspondingly great ; the weight of the anvil should be 14 times the weight of the hammer, and a ready means of calibration should be provided. If suspected regions are not known they should be sought for by polishing, etching, and microscopic examination, and with the object of revealing the minimum of, rather than the average, quality, the test-bars should be as small as possible, say $85 \times 10 \times 8$ mm. F. C. A. H. L.

544. *Tests of Nickel-Steel Riveted Joints.* (Univ. of Illinois, Bull. No. 49, Engineering, 94, pp. 768-764, Dec. 6, 1912. Abstract.)—Tests were made in pure tension of lap and butt joints of various types with and without fillers, or dead packings, made from nickel, chrome-nickel, and carbon steels. The former two were also tested in alternative tension and compression, for bending of rivets, deformation of joints and slip of plates. Test joints were $6\frac{1}{2}$ in. to $7\frac{1}{2}$ in. wide with from one to 18 rivets, but in no case were there more than two rivets in a line across the width. To detect bending of rivets, they were drilled axially $\frac{1}{4}$ in. diam. A series of Stub's steel rods was used varying from $\frac{1}{2}$ in. downwards, to gauge the curvature during testing, which could be estimated from the diam. of rod which would just pass. As a result of the tests it is stated that the shear resistance of the rivets is less if the plate material is harder than the rivets, and vice versa. Slip is greatly affected by workmanship. All joints show a definite "yield-point." Under alternating stress considerable slip occurs at low loads, but in these tests the ultimate strength is not appreciably less than in steady tension. As the number of alternations was small, the authors disclaim any suggestion that a large number of stress reversals would produce no fatigue. The "yield" under alternating stress does not appear to be lower. The ratio of yield to failure stress of a joint is about the same as that of the plate material. For joints designed with reference to ultimate strength, the use of special steels may be advantageous ; but their use in designs for frictional grip of rivets is of little value. Roughly, the strengths of joints are as 100 for carbon steel to 109 for chrome-nickel-, to 116 for nickel-steel. The carbon steel was, however, at the disadvantage of having holes punched and not reamed, with pneumatically closed rivets, and of being of a specification inferior to that of best British VOL. XVI.—A.—1918.

practice. The cover plates were also overstressed relatively to strength. Curves are given of the properties of increasingly complex joints in the three steels. Slip results are somewhat erratic specially for carbon steel, which is inferior to Ni- and Cr-Ni-steel, the latter being slightly the best. The unevenness is probably due to varying rivet grip and holes being out of truth. Both special steels show an upward trend in the more complex joints due to the better grip of longer rivets. At yield all three metals behave very similarly, nickel- being slightly better than chrome-nickel- and carbon-steel not much inferior. There is a uniform falling-off of yield resistance with increasing complexity, attributed to increased bending of longer rivets and to less perfect load distribution, the carbon-steel plates also usually being overstressed. Although it is hard to discriminate with the special steels between the value of rigidity of material and that of excess plate section, it is stated conclusively that the former favours high rivet resistance by minimising local yielding in detail. For ultimate resistance all three steels lie close together, nickel leading, in spite of their widely varying physical properties. It is noticeable that fillers stopping at the ends of covers cause a pronounced reduction of "yield" strength.

E. J. S.

545. Ice Friction under Pressure. H. Morphy. (Phil. Mag. 25. pp. 188-185, Jan., 1918.)—This investigation was undertaken at the suggestion of J. Joly, who thought it might be of interest in connection with his theory of skating, this theory being, as is well known, that skating is rendered possible by the formation of a film of water between skate and ice, owing to the melting of the latter under pressure. The experimental determinations consisted in the measurement of the coefficient of statical friction between the runners of a small sleigh, carrying a variable load, and the surface of ice kept at constant temperature. The angle of friction was found to remain constant until a certain stage of the loading, when it suddenly fell to about half its original value. It then remained constant for further increases in the load. The corresponding two constant values of the coefficient of friction are 0.86 ± 0.1 and 0.17 ± 0.01 respectively for the aluminium sleigh in use.

E. H. B.

546. Fixation of Units by Legislative Means. R. de Baillehache. (Rev. Générale des Sciences, Jan. 15, 1918.)—The French Minister of Commerce and Industry having asked the various commercial, industrial, and scientific communities whether the present would not be an opportune time to fix, by legislative means, new units, such as the units of force, heat, light, and electricity, the author reviews the whole question, mainly from the national standpoint and in anticipation of forthcoming legislation. In addition to the usual units of length, mass, etc., the term *Cop* is put forward for the absolute unit of force on the decimal metric system. *Unit of force.*—The *cop* (abbr. for Copernicus) is that force which, acting on a mass of 1 kg., gives it an acceleration of 1 m. per sec. per sec. In published works the additional unit of force, the hectogramme, could be used. A force of 1 hectogramme = 0.980665 cop. Conversely $1 \text{ cop} = 1.01972$ hectogramme (mass). *Unit of work.*—While the absolute unit of work or energy is the joule, in transactions the additional unit, the hectogramme-metre could be used ($1 \text{ hectogramme-metre} = 0.980665 \text{ joule}$). *Unit of power.*—The absolute unit is the watt : this is the power generated by the displacement of a force of 1 cop at a speed of 1 m. per sec. As additional unit the poncelet could be used ($1 \text{ poncelet} = 1 \text{ kw. approx.}$, more exactly 0.980665 kw. , and is $4/8$ of the older

cheval-vapeur of 75 kilogramme-metres). *Unit of pressure.*—The absolute unit is the decabarye [decabar] (or tor, abbr. for Toricelli), and is the pressure exerted by the force of 1 cop uniformly distributed of a surface of 1 metre-square. The submultiple ($\frac{1}{10}$) of this is called the *barye* (= pressure of column of Hg of 750.05 mm. height at 0° C.). In industrial work, the "atmosphere" to be retained (1 atmo. = wt. of column of Hg 785.5 mm. in height at 0° C. = 98066.5 decabaryes). The normal standard atmospheric pressure is = 101321.1 decabaryes or about 1 million *baryes*. The author then proceeds to discuss the definitions of the various units, and concludes with the hope that future legislation will recognise the beauty and harmony of the M.K.S. (metre, kilogramme, second) system. L. H. W.

547. *Quaternionic Relativity.* L. Silberstein. (Phil. Mag. 25. pp. 185-144, Jan., 1918.)—This is the second communication on this subject [see Abstract No. 1155 (1912)]. This work commences by the introduction of a simplified form of the force-quaternion, which is $P = -\frac{1}{4}G[D]F$. The D placed here between G and F denotes a differential operator which is intended to act both forward and backward. It is afterwards shown that the one operator $G[\]F$ furnishes (i) the force-quaternion, (ii) the corresponding stress, and (iii) the flux and density of energy, according as the vacant place in the brackets is filled by D , by a simple vector, or by a simple scalar respectively. Thus, the operator in question, does all the offices of Minkowski's matrix S of 4×4 elements or Sommerfeld's and Laue's "world-tensor." E. H. B.

548. *Non-Newtonian Mechanics.* R. C. Tolman. (Phil. Mag. 25. pp. 150-157, Jan., 1918.)—In this article it is shown that the Einstein transformation equations, and the other principles of non-Newtonian mechanics, lead to a number of further transformation equations for acceleration, mass, rate of change of mass, and force. The transformation equations of force are identical with those chosen by Planck. Two applications of the transformation equations are given. By combining them with Coulomb's law, the expected equations are derived for the force with which an electric charge in uniform motion acts on any other charge, and by combining them with Newton's laws of gravitation a new expression is derived for the gravitational force with which a particle in uniform motion acts on another particle. [See Abstracts Nos. 357 and 784 (1912).] E. H. B.

549. *Longitudinal and Transverse Mass.* J. Ishiwara. (Phys. Zeitschr. 14. pp. 26-29, Jan. 1, 1918.)—P. Frank [Abstract No. 29 (1918)] derived from purely dynamic and energetic premises formulæ for the longitudinal and transverse mass of a system which exactly agree with those of the relativity theory. He did this by adding to Abraham's relations a modification of Duhem's axiom, that "the work required to impart to a body of velocity u an additional velocity v in a direction normal to u is equal to the work required to impart to it a velocity v from rest." Frank makes the ratio of the two amounts of work equal to the ratio of the mass at velocity u to the mass at rest. The author regards this process as too artificial, and prefers another dynamical principle based upon the invariance of "action" with respect to space-time transformations. In a system at rest a body is given a small displacement by a known force. The work is measured both in the system at rest and in a moving system. The difference is equal to the work on a body moving in the system at rest with a velocity equal to the relative velocity of

the two systems. This leads to the conclusion that there is no change of mass with velocity unless space and time are given a new interpretation different from the classical one. The electron has probably a constant mass, and the observations of Kaufmann, Bucherer, and Hupka may have to be interpreted in a different way. E. E. F.

550. Oblique Impact of Two Confined Streams of Water. A. H. Gibson. (Roy. Soc. Edinburgh, Trans. 48. 28. pp. 799-811, 1918.)—Describes experiments on the loss of energy at oblique impact of two confined water jets. The following conclusions are drawn from the experimental results:—(1) The friction loss per foot run of such rectangular passages as were used, with sections varying from 1 in. \times 0.5 in. to 2.5 in. \times 0.5 in., is given by

$$h = 0.0086 v^{1.08} / 2gm^{1.20} = 0.000056 v^{1.08} / m^{1.20} \text{ ft.,}$$

where $m = (\text{area})/(\text{perimeter})$ in foot-units. (2) The loss at plain elbows of uniform rectangular section is given by $Fv^2/2g$ ft., where $F = 0.0000876 \theta^{2.17}$, θ being the angle of deviation of the elbow in degrees. (3) Where the elbow is formed by the junction of one pipe with a second, and so has a dead end facing the final direction of flow, the loss is increased. In such a case

$$F = [(m - 1)^2/m^2 + 0.00046 \theta^{1.8}/m],$$

where m is the ratio of the areas of the outlet and inlet legs of the elbow. (4) The loss L at impact of two confined streams, only one of which suffers deviation, is given by $L = av_1^2/2g + bv_2^2/2g$ ft.-lbs. per lb. of the impinging jet (2), i.e. the jet which is deviated on impact. The values of the coefficients a and b are tabulated and graphed. (5) The formula

$$L = [(v_2 \sin \theta)^2 + (v_2 \cos \theta - v_1)^2]/2g \text{ ft.}$$

gives results which, except in one or two particular cases, are totally unreliable. (6) Where the volumes Q_1 and Q_2 to be discharged by the two streams are known, and where the ratio m of their areas may be modified as required, the value of m for minimum loss is given by

$$m = 1 + 2\theta/100 + \sqrt{\theta} Q_1/11.4 Q_2.$$

(7) Where both streams are similar and each suffers the same deviation θ , the area of the combined streams being equal to the combined areas of the impinging streams, the loss is substantially the same as in an elbow of uniform section and with the same angle of deviation. A. W.

551. The Unsinkability of Modern Sea-going Ships. Flamm. (Engineering, 95. pp. 215-217, Feb. 4, 1918.)—Refers to the rules embodied in the printed Bulkhead Curves, and points out the danger involved in the fact that these curves do not take any account of the *stability* of the vessel when she is open to the sea. The argument is illustrated by diagrams of stability which are given for the s.s. *George Washington* (North German Lloyd), *Mauretania*, and *Titanic*. L. H. W.

552. Stability of Flow of, Incompressible Viscous Fluid. A. H. Gibson. (Phil. Mag. 25. pp. 81-84, Jan., 1918.)—As a result of experiment Osborne Reynolds concluded that the conditions tending to stability of flow, i.e. to stream-line as opposed to sinuous flow, of an incompressible viscous fluid are: (1) Free (exposed to air) surfaces. (2) Converging boundaries. (3) Curvilinear motion with the velocity greatest at the outside of the curve. (4) An

increase in viscosity. (5) A diminution in density. From an examination of the equations of motion he also showed that conditions (4) and (5) might be predicted from theoretical considerations. As regards conclusion (8), recent experiments by the author indicate that for increased stability in curvilinear motion the greatest velocity should be at the inside, not at the outside of the curve, and in the present paper it is shown that this, as well as the truth of conclusions (1) and (2), may also be inferred from the general equations of motion.

A. W.

553. Energy Law for Fluids. D. Bánki. (Zeitschr. Vereines Deutsch. Ing. 57. pp. 17-25, Jan. 4, 1918.)—Describes an experimental investigation of the law of flow for liquids streaming through curved tubes.

A. W.

554. Transverse Vibrations of a Rod of Varying Cross-section. P. F. Ward. (Phil. Mag. 25. pp. 85-106, Jan., 1918.)—An extension of some results given by Kirchhoff.

L. H. W.

555. Motion of Viscous Liquid due to Uniform and Periodic Motion Maintained over a Segment of an Infinite Plane Boundary. W. J. Harrison. (Roy. Soc., Proc. Ser. A. 88. pp. 18-23, Jan. 29, 1918.)—Theoretical.

556. Screw Propeller Design. C. W. Dyson. (Amer. Soc. of Naval Engineers, Journ. Engineer, 114. pp. 215-216, Aug. 30, 1912.)

557. Variations in the General Atmospheric Circulation in Temperate Latitudes. A. Defant. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 379-586, March, 1912.)—An investigation of the variations of daily amounts of rainfall over large areas in temperate latitudes in both hemispheres shows that they occur in several oscillations of definite periods travelling in an east-west direction. Four such waves can be distinguished, of which the lengths correspond respectively to the whole circuit of the earth in an east-west direction, and to the half, third, and fourth parts of that circuit respectively. The velocity of propagation of all the waves is nearly constant and amounts to $14^{\circ}5'$ per day on the year's average, so that each wave completes the circuit of the earth in about 25 days. The velocity is greater in the northern hemisphere than in the southern, greater in winter than in summer, and greater over the continents than over the oceans. The amplitude of the yearly variation shows local differences. All the observed variations in rainfall may be explained as consequences of the regular progression of corresponding waves of pressure. Rainfall is an index of the intensity of vertical motion upwards, but the latter is closely related with downward and horizontal motions and is therefore connected with the general circulation.

R. C.

558. High Tropical Winds. W. van Bemmelen. (Nature, 90. pp. 250-251, Oct. 31, 1912.)—Observations of pilot balloons in Batavia confirm the existence of a high westerly wind above the trades and anti-trades, immediately below the persistent easterly winds which are peculiar to the tropics, and which carried the dust from the Krakatoa eruption of 1888 many times round the earth at a level of about 80 km. The order of the currents is the following: (1) Shallow local breeze; (2) SE. trade wind, to 8 km.; (3) NE. anti-trade, to 17 km.; (4) upper SE. trade wind, to 18 km.; (5) high westerly wind, to 23 km.; (6) easterly Krakatoa wind, to at least 80 km. The velocities of the currents numbered (2), (3), (5), and (6) are about 5, 16, 12, and 85 m./sec. respectively.

R. C.

559. Investigations of Föhn. H. v. Ficker. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 829-878, May, 1912.)—The results of three balloon voyages from Innsbruck made during föhn winds, and the records from registering balloons liberated from Munich gave the following results. Before föhn commences at the surface it blows aloft from SE. over a cold surface layer, which covers mountains and valleys to an equal depth, and is usually also SE. in direction, although that is governed principally by the trend of the valleys. The boundary between the two currents is marked by a layer of strato-cumulus cloud. The direction of föhn itself when it appears at the surface is nearly independent of the contour of the land. It is, however, slightly deflected in the valleys, while it rises on the windward sides and descends on the lee sides of the mountains. Föhn is dissipated either by an invasion of cold air from the NW. below the upper SE. wind, or by a gradual accumulation of cold air at the surface. An adiabatic temperature gradient is found only along a definite stream-line: in a vertical direction the gradient is less than the adiabatic, but greater than the normal amount for the place and season. Change of wind direction with height is normal in the föhn itself, passing from SE. to SW. as the height increases. In the lower layer the normal surface wind at the commencement of föhn is SE., while at the end it is W. or SW. The change to the SE. of the föhn current is usually a discontinuous one.

R. C.

560. Temperature and Humidity in the Atmosphere on Occasions of Föhn. H. v. Ficker. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1225-1248, July, 1912.)—In a previous paper [see preceding Abstract] the author showed that föhn blows across the valleys at Innsbruck which trend east and west, descends the lee sides and ascends the windward sides of the mountains. The stream-lines near the ground thus follow roughly the surface contour, but they become crowded together over the summits of mountains and they open out over the valleys, until at some unknown height above the tops of the mountains they are undisturbed by the surface contour and are horizontal. Since the air is descending on the whole there are no condensation effects, and the potential temperature along a stream-line is constant, the actual temperature changing adiabatically. Again, because the vertical temperature gradient is smaller over the mountains than in the valleys, a fact which follows from the thermodynamics of the föhn, it follows that as one passes away from the mountains on the lee side at any given height the temperature rises, while relative humidity falls.

R. C.

561. The Diurnal Variation of Wind Force at the Summit of Ben Nevis. J. v. Hann. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 185-220, Feb., 1912.) Estimates on the Beaufort scale of wind force on Ben Nevis were made hourly during the time the observatory was open. The author deals mainly with 10 years' observations, 1884-1887 and 1898-1908. A Robinson anemometer was installed at the summit, but on account of the low temperature combined with the abundant precipitation it could not be used in winter and it was frequently put out of action in summer. From a comparison of 16 months' corresponding results of recorded and estimated winds, the conclusion is drawn that the factor for converting the estimates to true velocities in miles per hour is nearly constant throughout the scale, and for statistical purposes it may be taken to be 7.72. The unusual conditions at the summit are sufficient to account for this result, which is different from that deduced for sea-level stations, where the factor increases with increasing wind

velocity. At Ben Nevis, however, there is a well-marked diurnal period in the factor, for which no explanation is forthcoming; it being least, 7.48 at 8 p.m., and greatest, 8.11 at 8 a.m. As regards the daily variation of wind force, the maximum occurs with great regularity between 1 and 2 a.m. The minimum is more variable; from Nov. to March it occurs at 4 p.m., in April, May, and June at 5 p.m., in July, Aug., and Sept. at from 2 p.m. to 8 p.m. The variation of the maximum from the mean is greater than that of the minimum, consequently the wind remains below the mean value for more than half the day. The seasonal variation of the mean difference between daily maxima and minima shows two maxima, in Jan. and July, and two minima, in March and Nov. In spite of the high latitude, the high degree of cloudiness, and the lack of winter sunshine, the diurnal variation is thus very well marked in winter. The author finds it difficult to account for the variation, which is not dissimilar in character from that on European mountain peaks, by means of the usual explanation, which requires strong diurnal convection currents. He suggests that the cause of diurnal variations of wind on mountain peaks calls for further inquiry. An investigation of the frequency of gales shows that there is a well-marked double period in its diurnal variation, with maxima at midnight and 9 a.m. and minima at 5 a.m. and 8 p.m. This result is similar to those found for Vienna and for the German coast. [For the observations from which the author's results are derived see Abstract No. 1462 (1911).] R. C.

562. *The Geographical Distribution of Monthly Variations of Pressure.* W. Köppen. (Meteorolog. Zeitschr. 29. pp. 501-511, Nov., 1912.)—For the investigation of non-periodic variations of pressure, the author uses the mean difference between the highest and lowest barometer readings in each month [see Abstract No. 828 (1912)]. Plotting these on maps of the world, one for each month, and drawing lines through places where the variation is the same, curves are obtained which are called "isokatanabars" after Lockyer's "isanakatabars" which represent a different measure of the fluctuations. Previous results of the author are combined with recent work of Brockmüller [see Abstract No. 1633 (1912)], and two charts of Isokatanabars are shown, one for winter (Dec., Jan., and Feb. in the northern hemisphere, combined with June, July, and Aug. in the southern) and one for summer. The greatest variations occur at about latitude 60° in both hemispheres and the least at the Equator. The variations are greater (up to 45 mm.) in winter than in summer (up to 38 mm.). The lines run nearly parallel to the lines of latitude, and the amount of the variation is related to variations of temperature along the parallels as well as to the general fall of temperature from the Equator to the pole. R. C.

563. *Diurnal Variation of Temperature at Tor on the Red Sea.* (Cairo Scientific Journal, May, 1912. Meteorolog. Zeitschr. 29. pp. 479-480, Oct., 1912. Abstract.)—Tor is situated on the Gulf of Suez on the western coast of the Sinai peninsula. It shows in June an unusual diurnal temperature variation with a maximum of 29.1° C. at 8 p.m. At 8 a.m. and 2 p.m. the values are respectively 25.4° C. and 28.7° C. The relative humidity for the same month shows the inverse variation, i.e. the minimum occurs at 8 p.m. At Minia, on the Nile, in the same latitude, the variations are normal. The cause is to be found in the diurnal variation of wind direction. In the morning it is from W. and NW. and is therefore a cool and moist sea breeze, but in the

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afternoon and night it veers to NE. and E., and flows down from the mountains, bringing with it the high temperature of the land accentuated by the dynamical warming due to the descent.

R. C.

564. Suggestions for Frost Protection. K. F. Kellerman. (Washington Acad. Sci., Journ. 8. pp. 53-55, Feb. 4, 1913.)—The author puts forward a proposal to prevent the occurrence of frost in orchards by spraying hot water into the air around the trees. Calculations are made of the quantity of hot water which would be required to raise the temperature certain specified amounts. Apart from loss of heat by convection, etc., it is found that about 90 gallons of water at 90° C. would be required to raise the temperature of a layer of air 26 ft. deep covering one acre from — 1° C. to the freezing-point if the humidity was initially 80 per cent. It is suggested that the fog which would be produced would further help to maintain the temperature above freezing by hindering the loss of heat by radiation.

J. S. Dr.

565. Atmospheric Disturbances and Solar Radiation. C. Dorno. (Meteorolog. Zeitschr. 29. pp. 580-584, Dec., 1912.)—The variations of heat radiation, brightness of solar disc, and ultra-violet radiation during a period of atmospheric disturbance in Oct., 1912, are given for comparison.

C. P. B.

566. Diurnal Variations of Atmospheric Pressure. W. J. Humphreys. (Mount Weather Observatory, Bull. 5. 2. pp. 182-159, 1912.)—The author discusses the 24-hour and 12-hour components into which the normal diurnal variation of the barometer can be analysed, and investigates the effect of every agent that may be supposed to produce the observed phenomena. The 12-hour variation, which is much more definite and regular than the 24-hour variation, passes through two maxima at 10 a.m. and 10 p.m. local time, and through two minima at 4 a.m. and 4 p.m. The author regards the morning maximum and the afternoon minimum as being *forced* by the convection effects associated with solar radiation, which interfere with the normal course of east-west winds and thus affect the pressure; while the night maximum and the morning minimum are secondary disturbances caused by the joint action of the forced primaries through the agency of the free period of oscillation of the atmosphere of nearly 12 hours. The causes which prevent the variation from becoming larger are (1) friction, and (2) the probable slight discrepancy between the free period of the atmosphere and 12 hours exactly.

R. C.

567. Evaporation on the Nile near Khartum. R. Türistig. (Meteorolog. Zeitschr. 29. pp. 454-462, Oct., 1912.)—An instrument is described for measuring the amount of evaporation, and the results of observations made from 22 March to 16 April, 1912, are described. The chief results are: The mean temperature of the water is lower than that of the air, the difference varying from 6·8° C. in summer to 1·7° C. in winter. The variations of air-temperature are unconnected with variations of evaporation. Evaporation by day is about twice as intense as evaporation by night. It is greater in the morning than in the afternoon. The max. rate occurs between 8 and 11 a.m., being about 1·0 mm. per hour, while the minimum in the night is less than 0·8 mm. There is no connection between evaporation and relative humidity, nor between evaporation and wind direction. The force of the wind is almost entirely responsible for variations in the amount of

evaporation, and for the period considered it is found that 0.6 mm. and 1.0 mm. of water are respectively evaporated in each hour when the wind velocity is 14 and 24 km. per hour, while intermediate amounts are associated with intermediate velocities. The average daily amount of evaporation was 18.8 mm., the max. and minimum values being respectively 24.7 mm. and 6.8 mm.

R. C.

568. *Atmospheric Studies.* J. W. Sandström. (Mount Weather Observatory, Bull. 5. 2. pp. 88-181, 1912.)—In this memoir the author discusses some general propositions on the changes of condition of atmospheric air, on the energy transformations taking place in the atmosphere, and on the vortex motions of the atmosphere.

R. C.

569. *The Variograph, its Records and their Application to some Questions in the Theory of Thunderstorms.* W. Schmidt. (Meteorolog. Zeitschr. 29. pp. 406-414, Sept., 1912.)—[See Abstract No. 507 (1910).] The variograph is an instrument which records automatically the rate at which atmospheric pressure is changing. Ordinary coal-gas is passed through an apparatus for regulating its pressure, and is lighted at the end of the outflow tube. Between the pressure regulator and the lighted end the tube is connected with a large vessel full of gas. When the pressure remains constant the flame burns steadily, but when the pressure falls, gas escapes through the tube from the large vessel, until the pressure inside it is equal to that of the atmosphere outside; and consequently the gas flame increases in size. Conversely when pressure rises the flame diminishes in size. The variations of the flame are recorded by placing in it a bimetallic thermometer, which records on a rotating drum through a series of multiplying levers in the usual way. The record of the thermometer is thus a record of the rate of pressure-change, for the greater the rate of change the greater is the variation of the size of the flame from the normal. The author prefers the curves of rate of pressure-change (variograms) to the records of an ordinary barograph, because upon the variograms the quicker variations are more pronounced than the slower, and small changes in a steady rise or fall of pressure are shown much more clearly than on the barogram. Pressure waves of 8 to 10 minutes' period are found nearly always to precede local thunderstorms, and the waves are so regular that a stable arrangement of the layers of air is indicated, quite contrary to the generally accepted theory. The fact that thunderstorms are not observed with föhn in which an adiabatic state must prevail, is in favour of the deduction. The variograms for line squalls and thunderstorms show very clearly the sudden rise of pressure that is so characteristic on the barograms. In general the variogram shows a fairly sudden rise followed by a more gradual fall back again to the zero line, indicating that pressure first increases at a rapidly increasing rate, and then increases at a gradually diminishing rate. The wind and rain come on at the commencement of the second stage, *i.e.* at the end of the rapid increase in pressure. The curves for line squalls and thunderstorms are so much alike that it is concluded that the latter are usually due to the flooding of cold air in the same way as the former. The fact that the specific humidity is as frequently higher as lower after a thunderstorm shows that fresh air must have taken the place of that observed before the storm. Thunderstorms are probably developed as a result of instability, but they are propagated in air that is essentially in stable equilibrium. These conclusions apply primarily to the summer heat thunderstorms as observed in Austria.

R. C.

570. Graphical Method for Observation of the Motion of the Clouds with the Perspective Nephoscope. A. Lo Surdo. (N. Cimento, 4. Ser. 6. pp. 442-458, Dec., 1912.)—A modification of the Marangoni nephoscope [Abstract No. 11 (1908)] is described, which permits of the determination of the ratios between the horizontal and vertical components of the velocity of a cloud and its height, and of the azimuth and inclination. W. H. Sr.

571. Photoelectric Eclipse Measurements. J. Elster and H. Geitel. (Phys. Zeitschr. 18. pp. 852-855, Sept. 15, 1912.)—During the 1900 solar eclipse, observed in Spain, it was found that the recovery of the full sunlight was more rapid than its extinction. This was tested at Wolfenbüttel during the total eclipse of April 17, 1912, by means of the potassium photoelectric photometer devised by the authors [Abstract No. 1884 (1912)]. The photoelectric current observed ranged from 4.58 microamps. for full sunlight filtered through a blue Jena uviol glass to 0.6 microamp. at the maximum phase. The recovery shows practically a symmetry with the waning phase, but there is a lag of the light amounting to 1 or 2 per cent. This may be due to a slight diminution of the transparency of the sky produced by the moon's shadow. There is no evidence of a more rapid recovery. Some figures obtained at Palma, Majorca, in 1905, are added for comparison. E. E. F.

572. Spectrographic Observations of Sun's Rotation. J. B. Hubrecht. (Roy. Astronom. Soc., M.N. 72. pp. 5-27, Nov., 1912.)—The investigation formed the Cambridge portion of the co-operative scheme for determination of the sun's rotation, as decided at the Solar Union Conference at Mount Wilson in 1910 [Abstracts Nos. 802 (1909); 1486 (1911)]. Observations were made with the Littrow spectroscope, having a Michelson grating, a dispersion of 1.18 mm. per Å. being obtained with the fourth order. A series of preliminary observations were taken to determine the stability of the instrument, and then a series of plates throughout the year at the solar equator, giving the means of detecting variations in the equatorial velocity at a time of sun-spot minimum. The region allotted to Cambridge extended from $\lambda 4800$ to $\lambda 4600$, and a table of the lines considered is given, with the deduced equatorial velocity for each selected line. From the summary of velocities for the lines due to the different elements it is concluded that there is no strong evidence of systematic variation dependent on the assigned chemical origins of the lines. Advantage was taken of the fine weather during May and June, 1911, to obtain a series of observations all round the sun in addition to the Equator plates, the records being made so as to discriminate between the rotational velocities of the two hemispheres. This is done by taking comparisons from points 90° apart, instead of the usual method employing points 180° apart. Consistent evidence is obtained of a difference of about 0.186 km. per sec. The average equatorial velocity during 1911 is given as 1.86 km. per sec. C. P. B.

573. Photographs of Partial Solar Eclipse at Greenwich, April 17, 1912. (Roy. Astronom. Soc., M.N. 73. pp. 41-46, Nov., 1912. From Royal Observatory, Greenwich.)—Owing to this eclipse being of unusually large magnitude, it was arranged to obtain a series of photographs of the various phases with the Thomson photoheliograph of 9-in. aperture, with the object of determining the relative positions of the sun and moon, and the resulting correction to the moon's place. Fifteen photographs were obtained, the times of exposure being automatically recorded on the chronograph by

contact-pieces on the shutter plate. Details of the method of reduction are given, and a table showing the apparent errors in the tabulated places of the moon for each of the fifteen plates. C. P. B.

574. *Spectrum of Nova Geminorum* (1912). F. J. M. Stratton. (Roy. Astronom. Soc., M.N. 73. p. 72, Dec., 1912.)—Photographs of the later spectrum of the Nova were obtained at Cambridge on Dec. 6 and 12, 1912. The characteristic bands were those of hydrogen and the nebula lines at $\lambda 4864$, 5007. The hydrogen bands were about 25 \AA . wide. Mention is made of faint bands with centre near $\lambda 4800$, a region generally vacant in the spectrum of novæ during their later stages. C. P. B.

575. *Similarity of Variations of S Persei and of Sun-spots*. H. H. Turner. (Roy. Astronom. Soc., M.N. 73. pp. 116–124, Dec., 1912.)—In former papers a comparison has been made of the sun-spot curve with the light curves of long-period variables, chiefly with respect to the periods less than the main period of $11\frac{1}{3}$ years. Also Schuster has shown that in the case of sun-spots other periodicities, chiefly submultiples of a chief period of $88\frac{1}{3}$ years, are associated. The present note deals with the examination of the long-period variables for such associated periodicities. The most promising results have been obtained in the case of S Persei. Nothing is found in the variations of this star corresponding to the 13.5-year period in sun-spots. There is a period of 665 days in S Persei with no sensible 6.75-year period in sun-spots, and the question is discussed whether the sun-spot periods of 8.17, 11.12, 18.5 years correspond with the S Persei periods of 665, 845, and 1078 days. C. P. B.

576. *Algol-variable R. R. Draconis*. F. H. Seares. (Astrophys. Journ. 86. pp. 868–884, Dec., 1912. Contribution from the Mount Wilson Solar Observatory, No. 64. Science, 87. pp. 38–34, Jan. 8, 1918.)—Observations made with a $7\frac{1}{2}$ -in. equatorial of the variations of this interesting Algol variable gave a period of 2.881079 days. Normally the star is a little brighter than the tenth magnitude, but during minimum it becomes too faint for the above instrument, and observations have therefore been continued with the 60-in. reflector at Mount Wilson by means of photographic registration. From these the minimum brightness is given at 18.58. From the curves showing the comparison between photographic and visual measurements, it may be noted that for two magnitudes below normal light the photographic variation is closely represented by the visual light-curve. From that point on, the photographic variation is greater than the visual, the divergence amounting to about three-tenths of a magnitude in an interval of a magnitude and a half. For the greater part of the curve the variation is rapid, and the last portion of the change requires but 20 minutes. The data obtained indicate that the eclipse is total, showing the darker star to be the brighter of the two. C. P. B.

577. *Parallax of Weisse 592*. E. Kinberg. (Ark. för Mat., Astron. och Fysik, Stockholm, 8. 15. pp. 1–25, 1912.)—From measurements on plates taken during the period Oct. 18, 1907, to March 22, 1908, the parallax of this star is determined to be $\pi = +0.186'' \pm 0.060''$. Several values given by other investigators are referred to for comparison. C. P. B.

LIGHT.

578. Electrically-heated Microscope Slide. **F. G. Cottrell.** (Amer. Chem. Soc., Journ. 84. pp. 1828-1882, Oct., 1912.)—The apparatus was designed for the study of liquid crystals, but is convenient wherever a rapid adjustment of temperature under the microscope is desired. The essential feature is a uniform film of Pt deposited over the glass slide which is to carry the object, so thinly as not to seriously reduce its transparency, but still forming a continuous conductor for the electric current. By connecting this film in series with a rheostat to an ordinary 110- or 220-volt lighting circuit, any temperature from that of the room to nearly the melting-point of glass may be rapidly established. To minimise the danger of cracking, the glass slips should be small, say $\frac{1}{4}$ by 1 in., and thin (0.6 to 0.8 mm.). The thin Pt coating is deposited by means of the discharge (Zerstaubung) from a Pt kathode in high vacuum. The ends of the slip are coated more thickly, to serve as terminals, either by applying gold paint, or by dipping them in a collodion solution containing a small amount of gold or platinum chloride. In either case, the slide should be heated over a Bunsen burner until the organic matter is completely burnt out. Non-conducting materials may be examined by placing them directly upon the platinised surface; with electrolytes a slip of thin cover glass may be interposed. A. E.

579. Bispherical Reflecting Condenser for Ultramicroscopy. **H. Siedentopf.** (Ann. d. Physik, 89. 6. pp. 1176-1184, Dec. 28, 1912.)—Discusses first anastigmatic reflection at two spherical surfaces, with special reference to a Zeiss bispherical cardioid condenser. A geometrical construction for anastigmatic reflection at two spherical surfaces is given, also a mathematical treatment of the formation of the image at points not on the axis of the system. A. W.

580. Diffraction Images. **J. W. Gordon.** (Phys. Soc., Proc. 24. pp. 422-448, Oct., 1912.)—The author gives the theory of diffraction patterns in a comprehensive form and by means of an elementary mode of treatment. The simplification consists essentially in substituting as the surface of resolution the envelope which forms the boundary of an aplanatic pencil in place of the wave-front which occupies its aperture. The general doctrine is developed in 17 propositions, and the bearings of the theory are illustrated by reference to the optical problems connected with the formation of a spectrum by a diffraction grating; also by reference to the effect of stopping out the centre of an object glass, and again by the problem presented by the ultimate limit of resolving power in optical instruments. A. W.

581. Optical Properties of the Ions in Water. **A. Heydweiller.** (Phys. Zeitschr. 18. pp. 1010-1012; Discussion, pp. 1012-1018, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—The refractive power of a dissolved salt is almost independent of its ionisation, and is approximately equal to that of the solid salt. The dispersion in the visible spectrum is also almost independent of ionisation; it is nearly equal for salts with the same anion, but varies considerably if the kathion is kept constant and the nature of the anion is varied. In the ultra-violet region the

dispersion both of the ionised and un-ionised solutions can be expressed by a formula of the Sellmeier type; this is best used to express the *ratio* of the refractive power of the solution to that of pure water. The characteristic wave-lengths of the free vibrations are given as $168\ \mu\mu$ for the Cl ion, $185\ \mu\mu$ for the Br ion, $280\ \mu\mu$ for the I ion, as contrasted with $161\ \mu\mu$ for solid KCl, and $156\ \mu\mu$ for solid NaCl. In the *discussion*, **Rubens** pointed out that the free periods in the far ultra-violet depend on the oscillations of electrons, which are independent of the nature of the molecule, and may be expected to be the same whether the atoms are in the form of ions or of molecules. But the deep infra-red vibrations depend on the oscillations of the whole mass of the molecule, and might be expected to show large variations as a result of electrolytic dissociation. Actually, a strong salt solution reflects the "reststrahlen" of salt no better than pure water.

T. M. L.

582. Measurement of Colour. **A. C. Jolley and A. J. Bull.** (Phys. Soc., Proc. 24. pp. 417-421, Oct., 1912.)—A paper dealing with a series of experiments made with a view to ascertaining the form of optical instrument most suitable for the measurement of colour. All forms of colour-mixing arrangements in which intermittent light is required were omitted from the experiments, since intermittent illumination was found to produce a somewhat rapid fatigue of the eye, and hence the readings soon became of little value. The methods adopted are based upon the Young-Helmholtz hypothesis. It was found that any colour could be imitated by the admixture, in suitable quantities, of the lights of three suitably chosen narrow regions of the spectrum. The only three with which all shades could be matched were: for the blue primary a narrow region from 0.468 to $0.466\ \mu$, for the green the region from 0.529 to $0.535\ \mu$, and for the red from 0.684 to $0.644\ \mu$. Instead of adding these coloured lights broader primaries may be subtracted from the white light by the selective absorption of suitably chosen dyes, but in this case the difficulty of expression becomes a serious one, owing to the impossibility of securing dyes which absorb one primary region and transmit the remainder of the white light in equal proportions. Diagrams of the different forms of apparatus used are given; for details see original paper.

A. W.

583. Measurement of Spectrograms with Cylindrical Lens. **J. B. Hubrecht.** (Roy. Astronom. Soc., M.N. 72. pp. 28-31, Nov., 1912.)—To obviate the effect of grain in the photographic plate, when measuring spectrograms under high power with a micrometer, a cylindrical lens is placed between the eyepiece and the eye. This makes the appearance of the lines more homogeneous, and enables the bisections to be made with greater certainty.

C. P. B.

584. Primary Standard of Light. **H. E. Ives.** (Astrophys. Journ. 86. pp. 821-829, Nov., 1912.)—The author suggests a standard of light based on 1 watt radiation of max. luminous efficiency. This appears to be located near $0.546\ \mu$, the green line in the mercury spectrum. The definition of unit luminous flux would be as follows:—"The unit of luminous flux is the flux from a source radiating energy of max. luminous efficiency at the rate of 1 watt." With light of the prescribed character as much as 800 lumens per watt might be obtained. In applying such a standard special methods are necessary to meet the difficulties introduced by heterochromatic photometry. But the author believes that a standard method of measurement, based on the use of the flicker photometer under certain specified conditions, and the

application of the luminosity curve of the normal eye so as to avoid personal errors, might be contrived. [See also Abstracts Nos. 898A and 288B (1918).]

J. S. D.

585. Helium Gas Standard of Light. P. G. Nutting. (Bureau of Standards, Bull. 8, pp. 487-494, Nov. 1, 1912.)—Particulars have been given of some tests on tubes containing helium with a view to their being used as standards of light [see Abstract No. 661 (1908)]. It was then found that small differences in thickness in the bore of the capillary tubes used introduced errors and more uniform tubes, which were also fairly free from striations, have since been obtained. Details of the photometric tests to which these tubes were subjected are given. The mean deviation in candle-power per cm. length of tube is found to be 1.15 per cent., and the max. deviation in any tube 8 per cent. The chief improvement to be sought in the next series of tubes to be made is complete freedom from striations. J. S. D.

586. Modern Microscopical Optics with Special Reference to Fluorite Objectives. C. Metz. (Nature, 90, pp. 608-607, Jan. 30, 1918.)

587. Theory of Monochromators of Great Light Intensity. G. J. Elias. (Archives Musée Teyler, 1. Ser. 3, pp. 29-42, 1912.)—[See Abstract No. 859 (1911).]

588. Photo-spectrography with Concave Gratings. C. P. Butler. (Photographic Journ. 52, pp. 857-868; Discussion, pp. 868-864, Dec., 1912.)

589. Recent Advances in the Measurement of Light and Illumination. J. S. Dow and V. H. Mackinney. (Phys. Soc., Proc. 24, pp. 405-415; Discussion, pp. 415-416, Oct., 1912.)

590. Central Aberration in Compound Lenses. Relation between Central Aberration and Astigmatism at Edge of Field. H. Violette. (Journ. de Physique, 8. Ser. 5, pp. 46-54, Jan., 1918.)

591. First Steps in Telephotography. E. Marriage. (Photographic Journ. 58, pp. 55-59; Discussion, pp. 59-62, Feb., 1918.)

592. The Halo in the Ricefield and the Spectre of the Brocken. [Miss] A. Everett. (Nature, 90, pp. 570-571, Jan. 28, 1918.)—Discusses Richarz's communication [Abstract No. 1882 (1912)], and calls attention to a remarkable distortion of the solar limb, due to refraction, observed by the writer near sunset, in 1908.

L. H. W.

593. Magneto-optical Researches. O. M. Corbino. (N. Cimento, 4. Ser. 6, pp. 415-425, Dec., 1912.)—Experiments are described on the rotatory polarisation produced by the vapours of Na, Cd, Cu, and Zn, when subjected to the action of a magnetic field. For the first metal, a sodium flame was employed, and a rotation observed, but with the other three metals, which were vaporised by means of the electric spark, negative results were obtained, and the relation between absence of magnetic rotation and anomalous dispersion is discussed. A magneto-mechanical theory of light is suggested, which, however, experiments have failed to support.

W. H. Sr.

594. Emission, Absorption, and Intensity Distribution of Spectral Lines. F. Reiche. (Deutsch. Phys. Gesell., Verh. 15. 1. pp. 8-21, Jan. 15, 1918.)—A mathematical treatment of the subject, dealing with isolated narrow lines. A formula is derived for the intensity distribution (E_0) of a narrow spectral line, which gives symmetrical distribution about the centre of the line. The essential parameters of the curve are the damping, and the mean velocity of the emission centres. Special forms of intensity distribution depend on a parameter b , which is directly proportional to the damping and inversely proportional to the velocity of the emission-centres. If b is large, then we get "dispersion" distribution; if b is small, we get, at not too great distances from the middle of the line, Rayleigh's distribution. In the case of metal vapours in flames, the damping within wide limits depends only on the number of the flame-gas molecules per unit volume. With electrically excited gases in Geissler tubes the damping is proportional to the pressure. For infinitely thin layers and "dispersion" distribution, the half-width, to a first approximation, is given by two terms, the first of which is directly proportional to the pressure, the second being inversely proportional to the pressure. The dependence on the temperature is complicated. With Rayleigh's distribution, the half-width, to a first approximation, is a linear function of the pressure, the first part of the function being independent of the pressure and proportional to the square root of the absolute temperature. For infinitely thin layers the form of the intensity distribution curve is identical for emission and absorption lines. The same is true for layers of finite thickness. With dispersion distribution, the lines are considerably broadened for finite layers when the product of the density of the emission-centres and the thickness of the layer increases. With Rayleigh's distribution, this broadening is only small. The ratio of emission- and absorbing-power, E/A , within a narrow simple spectral line is a constant, independent of the damping and of the thickness of the layer. If the line radiation is a temperature radiation, as may be the case for metal vapours in the Bunsen flame, the value of E/A follows Planck's radiation law. Experimental evidence is adduced in support of the above conclusions. A. W.

595. Photography of Absorption Spectra. T. R. Merton. (Chem. Soc., Journ. 108. pp. 124-127, Jan., 1918.)—Gives a summary of the objections to the older photographic method (Hartley and Huntingdon's) of investigating absorption spectra. Measurements with the spectrophotometer [see Abstracts Nos. 88 and 1885 (1912)] can be made to give accurate quantitative results, but considerable practice is needed to give concordant results, and the probable error of the observations varies with the wave-length of the light used. The following method has been devised, which provides a simple and accurate method of obtaining extinction curves. A series of strips was photographed through a neutral Sanger-Shepherd plate of carefully standardised extinction, and between these a series of spectrum strips was obtained, using different thicknesses of the absorbing substance. By choosing a suitable time of exposure the points of equal extinction can be made to occur in each pair of strips at the density best suited for comparison. Light from a Nernst lamp, after passing through a water tank to remove heat rays, was rendered approximately parallel by means of a collimating lens, and then reflected twice (at 45° incidence) from mirrors M_1 and M_2 , finally being focussed on the slit of a Hilger wave-length spectroscopy, a photographic shutter being placed just in front of the slit. A Zeiss variable absorption cell was placed between the mirrors M_1 , M_2 . The thickness of the absorbing layer in this cell can be

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accurately measured by means of a screw adjustment. In conducting the experiment, the cell was filled with the pure solvent, and the standardised plate laid on it. Strips 1, 4, 7, 10, and 18 were exposed. The plate was removed, and the cell filled with the solution to be investigated. Strips 2, 3, 5, 6, 8, 9, 11, and 12 were now exposed through various thicknesses of solution. Hence the necessary data for plotting a quantitative extinction curve are obtained. The method offers very little practical difficulty; the time taken in the measurement is little longer than with the method of Hartley, and quantitative results can be obtained without the use of costly apparatus. A. W.

596. Series in Spectra of Tin and Antimony. T. van Lohuizen. (Zeitschr. wiss. Phot. 11. pp. 397-414, Feb., 1918.)—A continuation of the author's previous work. Using the formula previously given [Abstract No. 1698 (1912)] a number of series are shown to exist of the type called by the author "translation series," in the spectra of Sn and Sb. A. W.

597. Band Spectra of Various Gases. F. Burger and J. Koenigsberger. (Phys. Zeitschr. 18. pp. 1198-1199, Dec. 15, 1912.)—Gives first a discussion of the hypotheses advanced with reference to band spectra by Stark and by Küpferer and Koenigsberger [see Abstracts Nos. 1087 (1908); 1027 (1912)]. Experiments are also described which tend to confirm the authors' hypotheses. It is shown that with bromine and NO, no ionisation due to absorption of light can be detected, and that the carriers of the band spectrum and fluorescence in the visible spectrum cannot be free ions or electrons. Hence it is concluded that reversible chemical dissociation is not connected with ionisation, as would be the case if Stark's hypotheses were correct. A. W.

598. Series Systems in Spectra of Zinc, Cadmium, and Mercury. J. Stark. (Ann. d. Physik, 89. 6. pp. 1612-1616, Dec. 28, 1912.)—In a previous paper Paschen has given a number of series in the spectra of Zn, Cd, and Hg [see Abstract No. 1486 (1911)]. In that paper, among other things, he arranged the Hg line 2586.72 with the lines 4078.05, 2857.07, and 2564.14 in a new combination series. Stark shows in the present paper that the lines 4078 and 2586 cannot possibly belong to the same series. Observations made up to the present show that lines of the same series have intensities of the same order, are found in the same light sources, broaden in a similar manner, and so on. Now, the line 2586 is given well in the flame, but not the line 4078; in the positive part of the arc at very low pressures the line 2586 is far the most intense line of the whole region 8000-2000, the line 4078 having an intensity compared with it of not more than 1/50. Observations on the Zeeman-effect, the Doppler-effect in the canal rays, and on the Zn and Cd lines all lead to the same conclusion. A. W.

599. Ultra-violet Band Spectrum of Oxygen. W. Steubing. (Ann. d. Physik, 89. 6. pp. 1408-1430, Dec. 28, 1912.)—Describes research upon the effect of different gases, of varying current and gas pressure conditions on the production of the first ultra-violet band spectrum of oxygen. It is found that in pure dry gases, which contain neither free nor chemically combined oxygen, the first ultra-violet band spectrum of oxygen can be produced under no conditions, whether the pressure is greater than atmospheric or the lowest possible. This band spectrum, on the contrary, appears intensely in the purest oxygen, thoroughly dried, if care is taken that neither hydrogen nor
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carburetted hydrogen are present. The spectrum also appears when the gas under investigation contains oxygen either simply mixed, or chemically combined, though the greater the spectral sensibility of the gas, the less intense is the oxygen spectrum; the proportion of oxygen present and the gas pressure also have an effect. With higher pressures and temperatures the band spectrum becomes clearer and more intense. A. W.

600. *Doppler-effect of Canal Rays.* H. Wilsar. (Ann. d. Physik, 89. 6. pp. 1251-1812, Dec. 28, 1912.)—A continuation of the author's previous work [see Abstract No. 194 (1912)]. Wien's method was used to investigate the effects in hydrogen, oxygen, and nitrogen. The following results were obtained:—(1) The lines of the hydrogen spectrum for which Dufour has found a Zeeman-effect show no Zeeman-effect in the canal-ray spectrum. (2) Principal series lines of hydrogen were not found in the canal rays. (3) All the spark lines of oxygen appearing in the canal rays show a Doppler-effect of the same magnitude (in agreement with Paschen's observations) and have therefore a common carrier. (4) For the series lines of oxygen Wilsar could find (in opposition to Stark's observations) no Doppler-effect. (5) The carriers of a single oxygen band cannot persist in the kathode fall of potential, but do persist in the penetrating canal rays of a force-free space. (6) The nitrogen bands in the canal rays from the negative pole have (in agreement with Hermann) no Doppler-effect; the carriers of these bands persist in electric fields. (7) Single lines of nitrogen have shown the Doppler-effect. There must exist for these lines at least two different carriers, since the effect is observed with different magnitudes for different lines. (8) The magnitude of the Doppler-effect does not, for H, O, and N, vary as \sqrt{V} , but reaches a limit for a certain potential characteristic for each gas. (9) While the carriers of hydrogen in the canal rays possess a single charge, the corresponding carriers for oxygen and nitrogen have multiple charges. (10) A magnetic field has quite a similar influence on the Doppler-effect in oxygen-canal rays to that for hydrogen. (11) The canal rays of hydrogen are not appreciably retarded by passage through a gas; the particles with small velocities are therefore more strongly absorbed than those with greater velocities. (12) Hydrogen canal rays (especially those with small velocities) are reflected both from glass (as Hermann has found), and also from a metal (Al) surface. (13) The "retrograde rays" exist in the whole discharge chamber, and are similar, as regards velocity and absorption in the surrounding medium, to the normal canal rays. (14) The carriers of the displaced line originate from the kathode fall of potential; they pass through the surrounding gas without undergoing loss of velocity or imparting velocity to other particles. The stationary particles of the surrounding medium acquire no velocity due to the impact of the moving particles, but are rendered luminous and are the carriers of the stationary line. (15) Most gases can be rendered luminous by the canal rays of other gases. (16) Mercury vapour is rendered strongly luminous by all canal rays, but is either totally unable to give rise to the displaced line in the radiation of other gases, or else can do so to but a very small extent. A. W.

601. *Intensity Distribution in Canal-ray Spectrum.* J. Stark. (Ann. d. Physik, 89. 6. pp. 1185-1200, Dec. 28, 1912.)—A discussion of the subject based on the experimental results of the author, Wilsar, Fulcher, and others [Abstracts Nos. 194, 856, 1865 (1912)]. If I_v is the intensity of the displaced line of the canal rays of velocity v , n_v the specific number, i_v the current strength of

these rays in the canal-ray beam, k_v proportional to the mean intensity of the individual particles, then $I_v = k_v n_v = k_v i_v / ev$. According to this equation the intensity of emission of the displaced line, with k_v constant and the current strength i_v also constant, decreases as the velocity of the canal rays passing the field of view increases. It also appears that the relative intensity of the displaced line increases with increased velocity of the canal rays for decreased and for constant gas pressure. A. W.

602. *Theory of the Zeeman-effect observed in any Direction.* H. A. Lorentz. (Archives Musée Teyler, 1. Ser. 8. pp. 1-24, 1912.)—[See Abstract No. 767 (1911).]

603. *Magnetic Rotation and Inverse Zeeman-effect in Mercury Vapour.* H. Starke and J. Herweg. (Phys. Zeitschr. 14. pp. 1-5, Jan. 1, 1918.)—Righi's experiment, in which an electromagnet with perforated pole-pieces, between which a sodium flame burns, produces a yellow luminosity in a beam transmitted through crossed nicols as soon as the field is turned on, is usually interpreted in terms of Macaluso and Corbino's observation of a great anomalous rotation of the plane of polarisation in the neighbourhood of the sodium line, a rotation which has also been observed in the cases of potassium, lithium, and hydrogen [see Abstract No. 1865 (1912)]. The authors also observed it in the blue Sr line, both blue Cs lines, and very strongly in the green Tl line. They used a quartz mercury lamp to find whether the whole of this effect is explicable on the lines indicated by Macaluso and Corbino, and found that there is, besides, a true "Righi effect" within the absorption lines themselves. This, however, is only observed in the green Hg line and its satellites, not in the yellow. All the doublets of the green line and its satellites became brighter, but remained perfectly sharp. When the nicols are not quite crossed there is a continuous spectrum with a fine self-reversal line at 5461, which darkens on turning on the field, the dark satellites appearing at the same time. An echelon grating was used. E. E. F.

604. *Specular Reflection of X-Rays.* W. L. Bragg. (Nature, 90. p. 410, Dec. 12, 1912.)—It has been shown by Laue, Friedrich, and Knipping that the diffraction patterns which they obtain with X-rays and crystals can be explained by assuming the existence of very short electromagnetic waves in the radiations from an X-ray bulb, with a wave-length of the order 10^{-9} cm. The spots of the pattern represent interference maxima of waves diffracted by the regularly arranged atoms of the crystal. If this is so, these waves ought to be regularly reflected by a surface which has a sufficiently good polish, the irregularities being small compared with the length 10^{-9} cm. Such surfaces are provided by the cleavage planes of a crystal, and the author has therefore tried mica, which has a very distinct cleavage plane. A narrow pencil of X-rays, obtained by means of a series of stops, was allowed to fall at an angle of incidence of 80° on a slip of mica about 1 mm. thick. A photographic plate set behind the mica slip showed, when developed, a well-marked reflected spot as well as one formed by the incident rays traversing the mica and support. Variation of the angle of incidence left no doubt that the laws of reflection were obeyed. By bending the mica into an arc the reflected rays could be brought to a line focus. An exposure of only a few minutes sufficed to show the effect. Slips of mica $\frac{1}{16}$ mm. thick were found to give as strong a reflection as an infinite thickness, yet the effect is almost certainly not a surface one. Further experiments are in progress.

605. *Distribution and Quality of Secondary Röntgen Radiation from Carbon.* H. Pealing. (Phil. Mag. 24, pp. 766-789, Nov., 1912.)—It is known that when X-rays fall on a radiator the distribution of the secondary radiation is not in accordance with simple scattering theory, the most notable feature being a large excess of radiation on the emergent side, especially with hard beams. According to theory, the amount (I_α) of X-radiation scattered in a direction α with the primary is given by $I_\alpha/I_{90} = (1 + \cos^2 \alpha)$. Barkla also showed that a "fluorescent" radiation is excited in the radiator when the penetrating power of the incident radiation exceeds a certain value, the ratio I_α/I_{90} for this fluorescent radiation being unity for all values of α . In the present experiments the distribution of secondary radiation from carbon is examined with incident beams of various penetrating powers, and the results show, (a) when the primary beam is soft the secondary beam consists of scattered radiation and an "extra" radiation which is softer than the primary. The proportion of extra radiation in the forward direction is much greater than in the other direction. (b) When the primary beam is hard the secondary beam consists of scattered radiation, a larger proportion of extra radiation than when the beam was soft, and hard fluorescent carbon radiation. E. M.

606. *Direct Production of Characteristic Röntgen Radiations by Kathode Particles.* R. T. Beatty. (Roy. Soc., Proc. Ser. A. 87, pp. 511-518, Dec. 18, 1912.)—It is well known that many elements can be stimulated to produce characteristic X-rays. So far, the only successful method of obtaining the characteristic rays has been to place the element in the path of a beam of X-rays, whereupon it becomes a secondary radiator; and if the exciting X-rays have the necessary penetrating power, the characteristic rays will make their appearance. Kaye [Abstract No. 457 (1909)] showed that if an element, say Cu, is made the antikathode in an X-ray bulb it becomes a source of intense radiation characteristic of Cu. An explanation of this result was suggested by Barkla and Sadler, the assumption being that the effect is indirectly produced by the kathode rays through the intermediate action of X-rays. Using later knowledge of the amount of energy transformed in such an operation, the author calculates that the amount of characteristic radiation found by Kaye is about ten times greater than can be accounted for by such an indirect action. Experiments described in the present paper show that the bulk of the effect is due to a direct transformation of the kathode rays into characteristic X-rays; that the small remainder is due to the indirect action suggested by Barkla and Sadler; and that the direct and indirect effects happen simultaneously as soon as the speed of the kathode rays exceeds a definite value. The method of experiment is to measure the relative amounts and penetrating properties of the X-radiations produced when pencils of kathode rays of definite velocity fall on antikathodes of (1) thick Cu, (2) thick Cu covered with Al-foil sufficient to stop the kathode rays but not X-rays, (3) thin Cu covered with the same Al-foil, (A) Al. The effects with the various antikathodes may be divided into three parts: (1) The "independent radiation" or radiation depending in quality on the speed of the kathode rays only, (2) characteristic radiations produced by the half of the independent X-radiation which enters into the copper, and (3) characteristic radiation produced directly by the kathode rays. The observations show that both the indirect (2) and the indirect (3) characteristic radiations disappear when the speed of the kathode rays is below 6.25×10^9 cm. per sec. When the radiations appear the direct effect is

much greater than the indirect effect. Further, there is no diminution in the intensity of the independent radiation when the characteristic appears, showing that the atomic mechanisms which account for the two are not connected with each other.

E. M.

607. Similarity in Nature of X- and Primary γ -Rays. J. A. Gray. (Roy. Soc., Proc. Ser. A. 87. pp. 489-501, Dec. 18, 1912.)—Previous experiments have shown that less radiation is excited in carbon by the β -rays of RaE than in radiators of higher atomic weight, and consequently it is convenient to cut off the β -rays of RaE by graphite when the properties of the primary γ -rays are under examination. In this way the author shows in the present experiments that the primary γ -rays from a preparation of Ra (D + E + F) contain a very soft constituent whose mass-absorption coefficient (about 8.8 in Al) shows that it is softer than some types of X-radiations. Absorption experiments were also made on the γ -rays excited in Pb by the β -rays of RaE, and the various results show that there is no fundamental difference in the absorption of X- and γ -rays. Further experiments showed that the primary γ -rays from RaE excite the characteristic X-radiations (series K) of silver, tin, barium, cerium, praseodymium and neodymium just as very penetrating X-rays would. Experiments in scattering showed that the primary γ -rays of RaE behave similarly, both qualitatively and quantitatively, to ordinary X-rays.

E. M.

608. Number of α -Particles emitted by Thorium Emanation. J. Satterly. (Le Radium, 9. pp. 484-487, Dec., 1912.)—There has recently been some discussion as to whether ThEm and ThA give 2 or 4 α -particles between them. The author has made experiments in which the relative ionisation of ThEm and ThA to that of thorium itself is compared with the relative ionisation of RaEm to radium. In both cases the emanations are removed from solutions and transferred to an emanation electroscope for measurement. From the results of the experiments, combined with Geiger's results for the ionisations produced by α -particles of different ranges, it is deduced that both ThEm and ThA give one α -particle per disintegrating atom.

E. M.

609. Detection of a Single α -Particle. G. Hoffmann. (Phys. Zeitschr. 18. pp. 1029-1088; Discussion, pp. 1083-1084, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—A review of the methods of detecting single α -particles is first given. A new sensitive electrometer is then described which has a low capacity, and can be made to give 10,000 divisions (mm.) per volt. The needle of the instrument constitutes the electrode, and this moves in a horizontal plane over two semicircular charged plates at potentials about + and - 25 volts respectively.

E. M.

610. Absorption of β -Rays. J. A. Gray. (Roy. Soc., Proc. Ser. A. 87. pp. 487-489, Dec. 18, 1912.)—It is clear from various experiments that one of the main factors in the absorption of β -rays is the loss in velocity of β -rays in passing through matter. It follows that β -rays of a definite speed must have what may be called a maximum range, and also that an exponential law of absorption of β -rays can only be approximate. In the experiments described the absorption of the β -rays of RaE by paper was determined, using such thicknesses that the transmitted activity fell to less than 1/10000 of the initial

value with no absorption. The results show that the β -rays become more and more absorbable as absorption proceeds, *i.e.* the percentage transmission for the same thickness of paper decreases.

E. M.

611. *Absorption of γ -Rays of Radium C.* A. Brommer. (Phys. Zeitschr. 18. pp. 1087-1040, Nov. 1, 1912. Paper read before the 84. Naturforscherversammlung, Münster, Sept., 1912. Akad. Wiss. Wien., Ber. 121. 2a. pp. 1563-1588, Oct., 1912.)—In the experiments described special precaution was taken with regard to secondary radiation, which is now known to be an important factor in γ -ray measurements. Radium was used as source in amount varying from 40 to 680 mgm. RaCl_2 , according to the part of absorption curve under investigation. The substances investigated were Pb and Hg, the values for the absorption coefficients found being 0.588 and 0.641 respectively over a very large range (up to 9 cm. Pb). These values are both 8 % larger than those of Soddy and Russell.

E. M.

612. *Secondary γ -Rays excited by the β -Rays.* F. Soddy. (Phil. Mag. 24. p. 892, Dec., 1912.)—The author discusses the question of the origin of the γ -rays of Urx , which are considered to be primary rays and not secondary rays excited by the β -rays in the material of the vessel containing the Urx . The significance of the absorption coefficients of the γ -rays excited by β -rays in Chadwick's experiments [Abstract No. 481 (1913)] is also discussed.

E. M.

613. *Delta Rays produced by β -Rays.* N. Campbell. (Phil. Mag. 24. pp. 788-788, Nov., 1912.)—In previous papers [see Abstract No. 689 (1912)] the author has shown that the quality of δ -rays emitted from solids under the action of α -rays is independent of the velocity of the α -rays and the nature of the solid. In the present paper the result is extended to δ -rays, which are shown to be produced by β -rays, thus proving that the properties of δ -rays are a function neither of the properties of the ionising rays nor of the material which they ionise, *i.e.* they are a function of the properties of some mechanism which is concerned in all ionisation. It appears from the experiments that the emission of δ -rays from a solid is equivalent to ionisation in a gas. The β -rays used in the experiments were not primary β -rays but β -rays excited in various substances by the incidence of Röntgen-rays.

E. M.

614. *Recoil Atoms in Ionised Air.* A. F. Kovarik. (Phil. Mag. 24. pp. 722-727, Nov., 1912.)—When a radio-active atom disintegrates with the expulsion of an α -particle the recoil atom can be collected on a negatively charged plate. The present experiments were undertaken to ascertain the effect of strong ionisation on the transfer of the recoil atoms through air on to the negative plate. A plate activated with actinium active deposit was used as source, the recoil of the atoms of the β -ray product AcD from the α -ray product AcC being studied. A plate at 115 volts was placed 12 mm. from the active plate, and the air between them ionised by the α -particles from an α -ray tube containing 10 millicuries of radium-emanation which produced about 10^{14} ions per sec. between the plates. With the source of ionisation in position the amount of AcD which reached the negative plate was only about 10 % of the amount in its absence. An investigation was also made showing that the number of recoil atoms drawn to the negative electrode increases as the p.d. between the plates is increased, the distance remaining constant; and also that the number increases as the distance is decreased,

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the p.d. being constant. In these experiments no external ionising agent was employed. These results are naturally explained on the assumption that the recoil atoms only penetrate about $\frac{1}{10}$ mm. of air at N.T.P., when they become positive ions and lose their charge by recombination. Recoil experiments were also made, using plates of different polish for the active deposit plate. The number of recoil atoms collected was greater from surfaces of higher polish. During the experiments the periods of AcD and ThD were determined to be 4.71 and 8.07 minutes respectively. E. M.

615. *Radio-activity of Solutions of Uranium Salts.* L. Michiels. (Le Radium, 9. pp. 482-484, Dec., 1912.)—The author has studied the ionisation produced by solutions of uranium salts of different strengths, the ionisation being measured immediately above the surface. The activity was found proportional to the uranium (metal) content for the same volume of solution. The author suggests that such solutions can conveniently be used as standards for small activities. E. M.

616. *Active Deposit in the Atmosphere.* K. W. F. Kohlrausch. (Phys. Zeitschr. 18. pp. 1198-1199, Dec. 15, 1912.)—The author analyses the results of various observers, and concludes that enough active products are present in the atmosphere to account for natural ionisation. Thus the radium products on the average produce 1.56 pairs of ions per cm.² per sec. The penetrating radiation from the earth appears to produce only a small effect in free air although the effect may be appreciable in a closed chamber owing to excited radiations in the walls. E. M.

617. *Relative Intensities of the Earth's Penetrating Radiation on Land and Sea.* J. C. McLennan. (Phil. Mag. 24. pp. 520-527, Oct., 1912. Paper read before the Roy. Soc. of Canada, May 17, 1912.)—There is a marked lack of agreement between different observers in regard to the number of ions produced per c.cm. by the natural penetrating radiation, and the daily variations in its intensity. The author has therefore made determinations in various localities using the same apparatus (zinc walls 0.5 mm.) which was hermetically sealed so that there could be no possibility of air containing active-emanation entering it during the course of the investigations. The results show that there is practically no difference in the number of ions produced inside a closed receiver when the point of observation was taken inside either a brick or a stone structure at points so far separated from each other as Cambridge (England), Bowland (Scotland), and Toronto (Canada). The mean value obtained under these conditions was 9 ions per c.cm. per sec. Further, the observations showed that the buildings themselves contribute on the average more than 1 ion per c.cm. per sec. Readings were taken every day on a vessel during a voyage across the Atlantic, and the mean value found was 6.0 ions per c.cm. per sec. The number directly over the water of Lake Ontario was 4.4. Diurnal variations at either Cambridge or Scotland were found to be either non-existent or less than 8%. E. M.

618. *Radiations Old and New.* W. H. Bragg. (Nature, 90. pp. 529-582, Jan. 9, and pp. 557-560, Jan. 16, 1918. Discourse delivered before the British Assoc. at Dundee.)

619. *Radio-activity of the Hot Springs of Iizaka, Iwasiro.* D. Isitani and K. Manabe. (Mathematico-Physical Soc., Tōkyō, Proc. 6. 20. pp. 291-298, Oct., 1912.)

HEAT.

620. *Electric Heater with Automatic Thermostat.* A. L. Clark. (Amer. Acad., Proc. 48. No. 14. pp. 559-605, Jan., 1918.)—Of the type in which the heating current is cut off or reduced by a rise in the mercury in a fine tube. Over a 80-minute test, the temperature ranged between 190-194° and 190-218° with cutting-off of the current and between 190-196° and 190-204° when the current was reduced but not broken. L. H. W.

621. *Micropyrometer.* G. K. Burgess. (Washington Acad. Sci., Journ. 8. pp. 7-10, Jan. 4, 1918. Phys. Zeitschr. 14. pp. 158-160, Feb. 15, 1918.)—The method described in Abstract No. 2068 (1907) has now been arranged to be carried out by one observer with a combined instrument. An incandescent filament is mounted within the eyepiece of the microscope, and from the current in this filament required to match the brightness of the specimen on the heated Pt-strip, the temperature is calculated. This method is an improvement on that originally used in which corrections had to be made for emissivities, and sometimes for the surface tension of specimens. The precision is mainly dependent on the character of melting of the specimen. With gold and nickel, which melt very sharply, a precision of 1° or 2° C. is obtainable. The use of the micropyrometer for the estimation of the temperature of incandescent surfaces simultaneously with their examination is suggested. F. R.

622. *Improved Foule Radiometer and its Applications.* F. W. Jordan. (Phys. Soc., Proc. 25. pp. 66-78 ; Discussion, p. 78, Dec., 1912. Electrician, 70. pp. 668-669, Jan. 10, 1918. Abstract.)—The radiometer devised by the author [Abstract No. 1228 (1911)] is improved by (1) replacing the badly conducting glass enclosure and cardboard partition by others made of brass and copper respectively, (2) replacing the variable magnetic control of the movement of the vane by the elastic control of a quartz fibre, (8) shaping the channels in which the vanes move so that the angular deflection of the vanes is proportional to the rate of evolution of heat, and (4) reducing the size of the apparatus, so that it may be placed within a concentric brass tube, thereby excluding all extraneous heat except that passing through apertures in its sides, and maintaining the various parts at a more uniform temperature. The sensibility of such an instrument is 0.52 mm. per microwatt, so that it may be used for measuring feeble oscillating currents, being almost as rapid as a Duddell milliammeter. It may be adapted for measuring the heat given out by small quantities of radium, the radiant heat being directed through a small rock-salt or fluorite window in the brass tube, on to a thin metal disc supported centrally by a fibre in one of the compartments, and the rate of absorption of heat being measured by Callendar's or Ångström's method. A compensation method is described by which a modification of this apparatus could be employed for measuring the Thomson-effect, the product of the mean compensating current and the mean resistance of the halves of the wire, divided by the temperature-difference between the centre of the thin wire and its thick leads, giving the Thomson coefficient. W. H. Si.

623. *Attainment of a Steady State when Heat diffuses along a Moving Cylinder.* [Miss] A. Somers. (Phys. Soc., Proc. 25. pp. 74-76 ; Discussion, VOL. XVI.—A.—1918.

p. 76, Dec., 1912.)—It is shown that in Nettleton's method for the determination of thermal conductivities [Abstract No. 1112 (1910)] the time of attainment of a steady flow of heat along the column may be calculated from purely theoretical considerations, by solving the differential equation $Ka^2\theta/dx^2 - v\rho s \cdot d\theta/dx = \rho s \cdot d\theta/dt$, which gives the temperature at any point within the column, and applying the fact that the flow of heat past any point in the cylinder is given by $K \cdot d\theta/dx - v\rho s(\theta - \theta_0)$. The case of diffusion of a salt in solution up a tube may be treated in a similar manner.

W. H. Sr.

624. Method of finding the Conductivity for Heat. C. Niven and A. E. M. Geddes. (Roy. Soc., Proc. Ser. A. 87. pp. 585–589, Dec. 18, 1912.)—This method of measuring the conductivity for heat of bad conductors is an extension of the method previously applied to substances mostly in powder or small grains. In the present method the body is used in flat layers and the heat is supplied by passing an electric current through a thin layer of Dutch leaf. Details of the arrangement and of the calculations are indicated. The following results ($\times 10^{-4}$ C.G.S. units) were obtained :—

Paper	8.27	Cork carpet	2.645
Plate glass	19.284	Linoleum	8.518
Norwegian pine.....	8.076	Leather	8.286
Mahogany	8.42	Fireclay brick	14.854
Ash	8.651	Polished clay tile	17.415
Canary pine	8.916	Vulcanite	4.210
Teak	8.974	Sulphur	6.151
Oak	5.011	Paraffin wax	6.649
Felt (green)	0.74–0.8		

T. H. P.

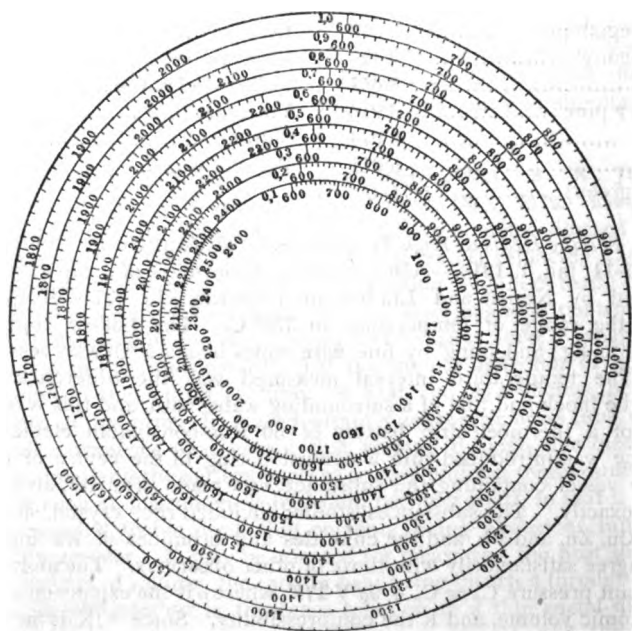
625. Specific Heats at High Temperatures. A. Magnus. (Phys. Zeitschr. 14. pp. 5–11, Jan. 1, 1913.)—Uses a copper calorimeter of a capacity 50 times that used by Nernst and Lindemann [Abstract No. 821 (1910)], so as to extend the range of temperature to 750° C. The hollow copper block weighed 22 kg., and hung by fine wire ropes inside a Dewar vessel 45 cm. deep. The temperature interval measured was the difference between that of the block and that of a surrounding water bath, and this was done by means of a thermoelectric battery of 50 iron-constantan elements. The substance was introduced into a conical boring in the centre of the block, and the vessel containing the substance was made of silver, and fitted the boring exactly. The substances studied included rock crystal, silica, oxides of Mg, Cu, Zn, and Pb, and the chlorides and bromides of Na and K. The results agree satisfactorily with those of other observers. The molecular heat at constant pressure $C_p = C_v + 9a^2V T/K$, where a is the expansion coefficient, V the atomic volume, and K the compressibility. Since V/K is nearly independent of the temperature, and a is proportional to C_p , we may put $C_p = C_v + C_p^*TA$. The constant $A = 2.7 \times 10^{-5}$ (Nernst and Lindemann). This formula, applied to NaCl, gives for C_p the value 12.10 at 831° abs. and 18.40 at 664° C. The observed values are 12.10 and 18.38 respectively.

E. E. F.

626. Theory of Specific Heat. M. Born and T. v. Kármán. (Phys. Zeitschr. 14. pp. 15–19, Jan. 1, and pp. 65–71, Jan. 15, 1913.)—Instead of dealing with a continuum, as assumed by Debye [Abstract No. 1178 (1912)], the authors apply normal co-ordinates to a system of an infinite number
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of degrees of freedom. A crystal is built up out of a Bravais space lattice of material points. The proper vibrations of these points are characterised by the phase differences ϕ, ψ, χ of every two molecules adjacent along the three axes respectively. Then it is proved quite generally that equal phase "districts" $\Delta\phi, \Delta\psi, \Delta\chi$ contain equal numbers of proper frequencies. This is put into another form thus: The number of proper-frequency triplets whose wave-length lies between λ and $\lambda + \Delta\lambda$ and whose wave normal lies in the solid angle $\Delta\infty$ is $Na^3 \cdot 1/\lambda^3 \cdot \Delta(1/\lambda) \Delta\infty$, where N is the number of molecules per mol and a is the molecular distance. The molecular frequencies include elastic vibrations. At low temperatures the specific heat is completely determined by the density and the elasticity. The atomic heat is, in fact $= 2.74 + 10^{10} \cdot m/\rho \cdot (T/c_m)^3$ gm. cal./deg., where c_m is the velocity of sound, m the atomic weight, and ρ the density. This formula is confirmed in Al and Cu, but less well in Ag and Pb at very low temperatures. The authors finally show how their formula may be converted into Debye's formula for an isotropic body. [*Errata*, *ibid.* p. 176, Feb. 15, 1918.] E. E. F.

627. *Scale for Calculating Thermodynamic Temperatures.* G. A. Shook. (Phys. Zeitschr. 18. pp. 940-942, Oct. 1, 1912.)—The outermost scale gives the



black-body temperatures from 600° to 2000°; the emissivity in this case = unity. The other circles give the corresponding thermodynamic temperatures of bodies having emissivities or absorption coefficients of 0.9, 0.8, . . . down to 0.1. L. H. W.

628. *Measurement of Temperature by Electrical Means.* C. B. Thwing. (Metallurgical and Chem. Engin. 11. pp. 86-88, Jan., 1918. Paper read before the Philadelphia Section of the Amer. Inst. Elect. Engin.)—A discussion of the methods of measuring temperature in different cases, describing the
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following types of instruments : (a) The simple thermo-couple ; (b) the radiation pyrometer with thermo-couple ; (c) the electric resistance pyrometer. For temperatures with a maximum range above 1500°C . the radiation type is the only one of the three which is available. Where the upper limit is 1500°C . the choice lies between the radiation and the Pt thermo-couple. Where the upper range is 1200°C . the chrome-nickel thermo-couple, the Pt thermo-couple, and the radiation type may all be used. For temperatures up to 1000°C . the iron-constantan thermo-couple comes first, but the Pt-resistance type is also available. For temperatures below 200°C . the iron-constantan thermo-couple and the nickel resistance may be used, but preferably the latter. In general when making temperature measurements a complex problem is being dealt with.

J. J. S.

629. *Thermometric Lag*. D. R. Harper. (Bureau of Standards, Bull. 8. pp. 659-714, 1912.)—The author investigates the time lag taking place before a thermometer registers a constant reading when immersed in a warmer or cooler environment. The mercurial thermometer first receives consideration. For the ordinary or chemical form Newton's law of cooling provides an adequate equation, viz. $\partial\theta/\partial t = (u - \theta)/\lambda$, where u denotes bath temperature at instant t , θ the thermometer reading at the same instant, and λ a constant with respect to u , θ , or t , although not independent of the form of the thermometer, the medium surrounding the latter, conditions of stirring, etc. For some forms of thermometer—*e.g.* those having an air layer separating part of the bulb from the bath—the simple theory fails and the physical meaning of λ has to be investigated. From the fundamental equation $\partial\theta/\partial t = (u - \theta)/\lambda$, λ has the dimensions of time. Equations are established showing that if a thermometer has been immersed for a long time in a bath whose temperature is rising at a uniform rate, λ is the number of seconds (the lag) between the time when the bath attains any given temperature and when the thermometer indicates this temperature ; also if a thermometer be plunged into a bath maintained at a constant temperature (the thermometer being initially at a different temperature), λ is the number of seconds in which the difference between the thermometer reading and the bath temperature is reduced to e^{-1} times its initial value. Special difficulties arise in the case of a falling meniscus due to sticking and even to separation of the mercury column ; hence the pseudo λ so obtained may or may not be related to the temperature lag of the bulb and so is of little value. In precision thermometry, therefore, a falling temperature should be avoided, although where necessary the thermometer may be subjected to a series of rapid jars.

The author establishes the principal equations for the three cases of constant temperature, linear rise, and exponential change of temperature, and describes experimental methods for the determination of λ , illustrative values being given. The variation of λ with stirring is studied and a special apparatus described in which the velocity of flow past the thermometer bulb can be measured. For the determination of lag under conditions approximating to infinite velocity the thermometer was plunged into steam, when the heat supplied instantaneously as steam, condenses on the bulb and maintains its surface at the temperature of the steam, and the author concludes the behaviour of the thermometer to be not very different from what it might be if an infinite supply of heat could be instantaneously brought to the surface of the bulb. The determinations in unstirred water give a wide latitude of variation, probably due to differences in convection currents. On account of the great variation in the rate of change of lag with velocity a short investiga-

tion with kerosene oil was undertaken to see whether the same general form of curve would be found. As might be expected, the more viscous liquid gives a greater value of λ for a given velocity, although the results are similar. The lag of a thermometer in air next receives attention, since it is great enough to affect results quite appreciably. In the usual case proper corrections are difficult to make, as the thermometer is subject to draughts of widely different velocities, no single value of λ holding for more than a few moments. The lag of a Beckmann thermometer requires additional assumptions for theoretical treatment, since $\partial\theta/\partial t = (\nu - \theta)/\lambda$ does not hold. The reason is suggested by the form of the instrument, since the main bulb is like that of an ordinary instrument, while the large capillary between the bulb and the zero of the scale acts as a second smaller bulb and, being enclosed in a tube with an air layer between it and the bath, is quite slow to assume the bath temperature. The modified equations deduced are justified by experiment.

For electrical thermometers some kind of galvanometer is necessary for the two forms, thermometric and resistance, and the lag of the galvanometers has to be added to that of the thermometer. It appears that the galvanometer lag was the greater portion of the whole and frequently the only portion to consider. Resistance thermometers were found to be either very fast or very slow compared with mercurial. The Jaeger-Steinwehr method of lag computation receives thorough discussion. The lag of a thermocouple is, like that of a resistance thermometer, found to be principally a question of the form of mounting.

Thermometric lag in calorimetry then receives detailed consideration. An analytical proof is given of the fact that in an experiment where the same thermometer is used to determine temperatures in the "pre-period," the "middle period," and the "after period," the correction for lag in the middle period neutralises those in the pre and after periods. Corrections for lag in applied thermometry are given in some detail. In a bath at constant temperature no correction is to be made if the thermometer reading be taken after a sufficient interval. For a linear temperature-change of r units per second the correction to get the bath temperature is $+r\lambda$ units, while when the temperature-change is a continuous single-valued function of time the lag is $+\lambda \cdot \partial\theta/\partial t$.

H. H. HO.

630. *Dispersive Power of Platinum Black.* C. Féry and M. Drecq. (Comptes Rendus, 155. pp. 1289-1241, Dec. 9, 1912.)—The behaviour of platinum black when exposed to radiation was observed by direct measurement. A sheet of Pt 0.08 mm. thick was covered with platinum black by means of electrolysis on both faces and placed in front of an electric furnace. By means of a Féry pyrometric telescope connected with a galvanometer the radiation from the front and back of the plate was measured exactly. Thus the coefficient of absorption of platinum black was found to be 0.82, the temperature being between 1250° and 1482° abs. The result shows that platinum-black is not superior to lamp-black for absolute measurements of radiation. The temperature of the lamina was 18 deg. above that of the surrounding medium. The arrangement was used to make a new determination of the important coefficient a in Stefan's law, and hence of $\sigma = \pi a$. If an electric current is caused to pass through the Pt sheet, the furnace not being in action, it may be proved that the temperature of the sheet is the same on the two faces, which is a guarantee of the symmetry of the blackening. If then a curve is constructed of the deviations given by the telescope (energy radiated by the sheet) as a function of the electric power expended in this same sheet,

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a straight line is obtained. There may then be referred to this straight line the power corresponding to anterior radiation W_a and the posterior W_p from the sheet when it is exposed to the electric furnace. The energy dissipated by the sheet is then $W = W_a/2 + W_p/2$, for the straight line standardised by the current gives the energy dissipated by the two faces of the sheet. But the energy given out by the furnace may be calculated, and is equivalent to that measured electrically. Thus $W = aT^4(SS'/D^2)$, where a is the coefficient sought, T the absolute temperature of the furnace, S the surface of the sheet, S' that of a screen of water placed in front of the furnace with an opening in its centre, and D the distance from this screen to the sheet. From the mean of the measurements thus made the value $a = 1.97$ was found, and $\sigma = 6.20 \times 10^{-12}$ (watts/cm.² degree⁻⁴). This value is a little lower than that obtained previously by the authors because the diffused heat does not follow Lambert's law, and the measurement of the energy in a single direction is insufficient to determine correctly the energy diffused by the anterior face. The measurement of the watts by the posterior face gives $\sigma = 5.57$, which agrees with previous measurements made with plane receivers. J. J. S.

631. Surface Combustion. J. R. Thompson. (Phys. Zeitschr. 14. pp. 11-15, Jan. 1, 1918. From the English.)—Studies the mechanism of combination of hydrogen and oxygen in contact with hot surfaces. Mixtures of the gases in various proportions were introduced into a glass tube containing a heated Pt spiral, whose temperature was deduced from its resistance. An Al cylinder surrounding the spiral was connected with an electrometer, and served to determine the point at which ions were emitted by the hot Pt. This took place when its resistance was about 8.5 ohms, and increased very rapidly above 10 ohms. Mixtures of H and O containing from 8.6 to 26% H were then introduced under pressures of from 11 to 22 cm. Hg, and the wire was heated until the explosion took place. This was always at the temperature at which ions were discharged from the Pt. Its resistance ranged from 8.01 to 8.59 ohms. The explosion was thus dependent upon the emission of ions. There was no slow combustion. Similar results were obtained on substituting a carbon filament for the Pt-wire. That the action is not a simple temperature effect was proved by making the Pt emit ions under the influence of X-rays. A suitable mixture was instantly exploded by turning the rays on to the metal. E. E. F.

632. Energy-Content of Gases. W. Nernst. (Phys. Zeitschr. 18. pp. 1064-1068; Discussion, pp. 1068-1069, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—Since the specific heats of solids are completely reduced to the author's formula, and liquids offer hitherto insuperable obstacles to a corresponding treatment, the next matter approaching settlement is that of the energy-content and specific heat of gases. Berthelot's equation of condition enables us to deduce molecular heats at constant pressure or volume from the critical pressures and temperatures. All data must be reduced to ideal gas conditions. As regards experimental methods, Pier and Bjerrum have carried the explosion method up to 8000° C. Eucken has devised a method for low temperatures based upon the fact that the capacity for heat of copper or steel vessels becomes very small in extreme cold. At ordinary temperatures the relation $C_p = 3R/2$ holds exactly for monatomic gases, but at low and high temperatures the relation is probably more complex. The relations $C_p = 5R/2$ for diatomic and $6R/2$ for polyatomic gases is reasonably verified. E. E. F.

633. *Molecular Phenomena not in agreement with Thermodynamics.* M. v. Smoluchowski. (Phys. Zeitschr. 18. pp. 1069-1079 ; Discussion, p. 1080, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—The Brownian molecular motions, the opalescence of gases in the critical state, the blue of the sky, and some other phenomena have led to a decision in favour of a real kinetic theory of gases as distinct from the traditional purely phenomenalist thermodynamics. The difference is most clearly brought out by a definition of the steady state. This used to be considered to be the state of minimum potential, to which an undisturbed body gradually approximates. The molecular kinetic view, on the other hand, admits the probability of continual fluctuations about this state, and of occasionally serious departures from it. The Brownian motions of particles denser than the containing liquid lead to a distribution according to a "barometric" exponential law, instead of a collection of all the particles at the bottom of the vessel. The work of Perrin on liquids, and Ehrenhaft and de Broglie on gases has confirmed this fully. The rule that the mean square of the concentration equals the reciprocal of the molecules contained in it has been successfully applied by Svedberg to gamboge emulsions and colloidal gold solutions. The author shows how opalescence is due to the fluctuations in density of a gas. E. E. F.

634. *Second Virial Coefficient for Monatomic Gases and for Hydrogen below the Boyle-point.* W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 51. pp. 648-649, Nov. 28, 1912. Supplement No. 26 to Communications from the Phys. Lab., Leiden.)—On the assumption that the attraction potential between the molecules may be expressed in the form $-\frac{a}{r^4}$, where r is the distance between the centres of the molecules and a a constant, hydrogen, argon, and helium have been investigated at low temperatures in order to ascertain the value of a . With argon, the experimental data available are insufficient to decide between the values 8, 4, and 5, but the behaviour of hydrogen below the Boyle-point seems to be in moderately good agreement with the assumption of rigid spheres of central structure with an attraction potential proportional to $-\frac{a}{r^4}$. In the case of helium, at temperatures below -100° the data also point to the value 4 for a , although at higher temperatures the data are discordant. T. H. P.

635. *Isotherms of Diatomic Gases and their Binary Mixtures. X. Control Measurements with the Volumenometer of the Compressibility of Hydrogen at 20°C .* W. J. de Haas. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 295-299, Oct. 24, 1912. Communication No. 127A from the Phys. Lab., Leiden.)—The compressibility of hydrogen at 20°C . is expressed by the equation, $p v_A = 1.07258 + 0.000687 d_A + 0.00000099 d_A^2$, where p is the pressure, v_A the volume in terms of the normal volume, and d_A the reciprocal of v_A . On account of the small densities occurring in measurements made with the volumenometer, the d_A^2 term may be neglected. Comparison of the results obtained with those given by earlier investigators shows satisfactory agreement. [See Abstract No. 1870 (1911).] T. H. P.

636. *Isotherms of Diatomic Gases and their Binary Mixtures. XI. Determinations with Volumenometer of Compressibility of Gases under Small Pressures and at Low Temperatures.* W. J. de Haas. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 299-306, Oct. 24, 1912. Communication No. 127B from the Phys. Lab., Leiden.)—The author discusses the pressure equilibrium
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between the piezometer and the volumenometer used in the measurement of the compressibility of gases at low temperatures [see next Abstract] and deduces a formula for determining the change in the pressure-difference between the two communicating vessels as a function of the time; this formula is derived from the dimensions of the apparatus and from data determining the distribution of temperature along the glass capillary. Application of the formula to a particular case gives results in complete agreement with those observed. The conditions for the rapid establishment of pressure equilibrium are defined.

T. H. P.

637. Isotherms of Diatomic Substances and their Binary Mixtures. XII. Compressibility of Hydrogen Vapour at and below the Boiling-point. H. Kamerlingh Onnes and W. J. de Haas. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 405-416, Oct. 24, 1912. Communication No. 127c from the Phys. Lab., Leiden.)—To the temperature region covered by previous investigations on the equation of state for hydrogen at low temperatures the authors now add that lying between -252° and -258° , measurements being made at -252.6° , -255.5° , and -257.8° ; these temperatures are expressed on the absolute scale. The value of the second virial coefficient B_A of the equation $p v_A = A_A + B_A d_A + C_A d_A^2$ is found to be -0.00047 , -0.00049 , and -0.00055 at -252.47° , -255.82° , and -257.10° respectively. The corrections to be applied to reduce temperatures of -252.59° , -255.45° , and -257.24° on the international hydrogen thermometer to the absolute scale are $+0.118^{\circ}$, $+0.125^{\circ}$, and $+0.144^{\circ}$ respectively.

T. H. P.

638. Radiation Constant. H. B. Keene. (Roy. Soc., Proc. Ser. A. 88. pp. 49-60, Jan. 29, 1918.)—According to the Stefan-Boltzmann law, the radiation emitted by a full radiator to surroundings at a temperature of absolute zero is proportional to the fourth power of the absolute temperature of the radiator, or $R = \sigma \theta^4$, where R = radiation in ergs per cm^2 per sec., θ = absolute temperature of radiator, σ = radiation constant. The apparatus consists of an electric furnace of the Heraeus type as *emitter*, and a thin copper spherical surface as *receiver*. Outside this was another concentric sphere, and between the two the space constituted the bulb of an aniline thermometer with a capacity of 2 litres, the stem being about 1 mm. bore. The chief results are as follows:—

Temperature of Furnace.	Constant, $\sigma \times 10^8$.
1117	5.98
1115	5.86
1119	5.90
1120	5.90
1097	5.87

in ergs cm^{-2} sec. $^{-1}$ deg. $^{-4}$

E. H. B.

639. Theory of Radiation. S. B. McLaren. (Phil. Mag. 25. pp. 48-56, Jan., 1918.)—This paper is an attempt to save the classical view of radiation as a continuous wave motion. If that can be done the author deems it a small thing to sacrifice the ordinary mechanical notions of matter. Indeed it is here considered that some such idea as that of Einstein's quantum is necessary to explain its most elementary properties. It need not be any

obscure inference from the laws of radiation. The various forms of matter are not in a continuous series; the gaps may be crossed in a radio-active transformation, but are not occupied.

The analysis then developed leads to the conclusion that to save the ether it is necessary to give up the classical mechanics. A formula for complete radiation is suggested which gives a similar result to Rayleigh's for large values of $\lambda\theta$ and to Wien's for small values. E. H. B.

640. Wien-Planck's Radiation Constant. E. Warburg, G. Leithäuser, E. Hupka, and C. Müller. (Preuss. Akad. Wiss. Berlin, Ber. 2. pp. 85-48, 1918.)—Experimental determinations were made of the constant c in the Wien-Planck radiation law, both with a quartz prism and with a fluorspar prism. The results are as in the table below :—

Wave-lengths. λ	Temperatures T_1 T_2	Quartz Prism.		Fluorspar Prism.
		1337°. 1673° F.	1673° F. 2998° F.	1337°. 1666° F.
0.6568		14,885	14,885	14,608
1.182		14,895	14,854	14,491
1.829		14,886	14,851	14,578
1.588		14,860	14,870	14,599
2.172		14,879	14,425	14,625
Mean values of c		14,881	14,867	
		14,870 \pm 40		

E. H. B.

641. Relative Temperature Scales of Solids. H. Alterthum. (Deutsch. Phys. Gesell., Verh. 15. 2. pp. 25-33, Jan. 30, 1918.)—A theoretical discussion on the Planck-Einstein *quanta* theory. [See Abstract No. 446 (1918).]

E. H. B.

642. Equation of State for Solid Bodies. H. Alterthum. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 65-68, Feb. 15, 1918.)—Mathematical. [See Abstract No. 508 (1918) and preceding Abstract.]

E. H. B.

643. On the Stability of Thermal Equilibrium. P. Duhem. (Comptes Rendus, 156. pp. 597-598, Feb. 24, 1918.)—Theoretical thermodynamical discussion.

644. Destruction of Boltzmann's Entropy Principle of the Second Virial-coefficient for Material Particles (in the Limit Rigid Spheres of Central Symmetry) which exert Central Forces, etc. W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 256-278, Sept. 8, 1912. Supplement No. 24B to Communications from the Phys. Lab., Leiden.)—[See Abstract No. 1856 (1912).]

645. Theory of Black Radiation. M. Brillouin. (Comptes Rendus, 156, pp. 301-304, Jan. 27, 1918.)

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SOUND.

646. Analysis of Violin Sound-waves. C. W. Hewlett. (Phys. Rev. 85. pp. 859-872, Nov., 1912.)—This work is a continuation of that begun by P. H. Edwards [see Abstract No. 635 (1911)], and the same method is used, viz. a set of adjustable resonators (in this case 89, from 128 to 2552 per sec.), each provided by a Rayleigh disc, set at an angle of 45° , in its mouth. Then when the resonator responds the disc tends to set across the mouth, and the deflection is observed by a spot of light on a scale. To obviate reflection from the walls of the room, a fluffy, fibrous substance called Linofelt was used to cover them. The open strings G, D, A, and E were tested on a number of violins of poor, ordinary, and high quality, and sixteen sets of records are shown. One of these indicates what is regarded as ideal violin tone, being derived from what seemed best on the individual records. E. H. B.

647. Compound Vibrations of Fork. E. H. Barton. (Nature, 90. p. 486, Dec. 19, 1912.)—Points out that the presence and relative frequency of an upper partial vibration of a tuning-fork can be shown by a smoke trace. The note includes a print of three smoke traces for the same fork: one shows the prime alone (128 per sec.), another the second tone alone, a third the combination of the two executed together. This compound vibration is easily obtained by striking the prongs on a hard surface such as a counter. The relative frequency of upper partial and prime were about 6.25 : 1. [See Abstract No. 202 (1913).] E. H. B.

648. Application of Resonators to Telephone Tones. M. Wien. (Phys. Zeitschr. 13. pp. 1084-1086; Discussion, pp. 1086-1087, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—Describes the application of spherical air resonators to telephones both for the generation of pure tones and for the detection of the same when very feeble. It is considered that useful applications are possible in connection with (1) the physiology of the ear, (2) Wheatstone bridge tests, and (8) wireless telegraphy. E. H. B.

649. Physical Objectivity of Combination Tones. E. Waetzmann and G. Mücke. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 59-65, Feb. 15, 1918.)—As prime tones were used the sounds of (i) forks from 200 to 4000, (ii) a set of organ pipes from 128 to 1024, and (iii) small glass pipes from 1800 to 3000 per sec., which were at first chiefly adopted. These prime tones were led to a microphone and an adjustable loud-speaking telephone. The vibrations of the telephone membrane were photographed by aid of an F. F. Martens mirror arrangement and a sensitised paper on a rotating drum. As source of light an arc lamp with horizontal positive carbon was employed. A set of three photographs shows the result of one experiment and gives the vibration curves for the primaries and their resultant. The former had frequencies $p/2\pi$ and $q/2\pi$, where p and q are 2200 and 1925 respectively. The resultant curve exhibits the following three elements:—

Frequency Coefficients.	Amplitudes.
$p = 2200$	1.1
$q = 1925$	0.8
$p - q = 275$	8.4

[See Abstracts Nos. 1760 (1905) and 1789 (1906).]

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

650. *Dynamics of the Electron.* A. Signorini. (N. Cimento, 4. Ser. 8. pp. 257-304, Oct., and pp. 331-375, Nov., 1912.)—An attempt to develop a mathematical theory of the motion of an electron in an electromagnetic field without subjecting the electron itself *a priori* to any kinematical linkage. The only distinctive property utilised is that its dimensions are infinitesimal with respect to those of the field. Following Larmor's mechanical conception, the electrons are considered as systems possessing a finite number of degrees of freedom. In the Lagrangian function of the mechanical model (excepting the connection between kinetic and potential energy) Abraham's assumption is made, in which only electrokinetic elements appear, such as the distribution of charges and currents, and retarded relative potentials. Levi-Civita's asymptotic expression is taken for the retarded potentials, and the previous history of the motion of the electron is thus eliminated. For any given position of the electron and for a given distribution of currents and charges, the motion of the electron, which has 12 degrees of freedom, is defined by a system of 12 ordinary scalar differential equations of the second order, in which the time appears as an independent variable. E. E. F.

651. *Decrease of Speed of Electrified Particles on passing through Matter.* N. Bohr. (Phil. Mag. 25. pp. 10-31, Jan., 1913.)—In this paper the theory of the decrease of velocity of moving electrified particles in passing through matter is given in a form, such that the rate of the decrease depends on the frequency of vibration of the electrons in the atoms of the absorbing material. It is shown that the absorption of α -rays in the lightest elements can be calculated from the information about the number and frequencies of the electrons in the atoms which we get from the theory of dispersion, and that the values are in good agreement with experiment. For elements of higher atomic weight, it is shown that the number and frequencies of the electrons we must assume, according to the theory, in order to explain the absorption of α -rays, are of the order of magnitude to be expected. It is further shown that the theory can account for the form of the relations between the velocity of the rays and the thickness of matter traversed, found by experiments with cathode-rays and β -rays. Adopting Rutherford's theory of the constitution of atoms, it seems that it can be concluded with great certainty, from the absorption of α -rays, that a hydrogen atom contains only one electron outside the positively-charged nucleus, and that a helium atom only contains two electrons outside the nucleus. E. H. B.

652. *Possible Changes in Weight or Momentum of Charged Condenser.* P. G. Agnew and W. C. Bishop. (Phys. Rev. 85. pp. 470-476, Dec., 1912.)—There is no reason to suppose that the weight of a body is affected by its state of electrification in great enough a degree to be detected by the methods of direct weighing at present available. Yet however improbable such an effect may seem, the question cannot be settled without an appeal to experiment. Similar investigations have been made to detect possible changes in
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weight due to temperature and to magnetisation and gave, as was anticipated, negative results. The same remark applies to the present research which may be summarised as follows :—(1) Charging a 10-mfd. condenser to 240 volts did not change its weight by 0.01 mgm., or one part in a hundred millions. (2) In charging and discharging the same condenser no momentum effect having opposite signs on charge and discharge as great as 0.01 dyne-sec. was detected. (8) Similarly no momentum effect having the same sign on charge and on discharge as great as 0.0004 dyne-sec. was detected. E. H. B.

653. *Electric Conduction in Metals.* W. Wien. (Preuss. Akad. Wiss. Berlin, Ber. 7. pp. 184–200, 1918.)—Mathematical discussion on the *quanta* hypothesis. The results reached are in close agreement with the theoretical and experimental results of K. Onnes. E. H. B.

654. *Vibration and Residual Charge.* P. L. Mercanton. (Archives des Sciences, 35. pp. 48–56, Jan., 1918.)—Hopkinson, following the analogy between residual charge and magnetic polarisation, investigated in 1876 the effects produced by vibration on the residual charge of a Leyden jar. He found that mechanical shocks always accelerated the appearance of the residual charge. The author has carried out many similar investigations but in no case has he found that vibrations have any effect in accelerating the appearance of the residual charge. Brentano also has obtained negative results. The reason of the great divergence between their results and those of Hopkinson are still obscure. A. R.

655. *Imperfect Dielectrics.* K. W. Wagner. (Deutsch. Phys. Gesell., Verh. 15. 2. pp. 45–46, Jan. 80, 1918.)—A note on the anomalies of solid dielectrics, residual charge, energy loss in alternating fields, etc. [See Abstract No. 650 (1908).] E. H. B.

656. *Stereoscopic Lightning Photographs.* B. Walter. (Phys. Zeitschr. 13. pp. 1082–1088; Discussion, pp. 1088–1084, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—Photographs of lightning flashes were taken simultaneously with three cameras, two of them mounted 2 m. apart on a fixed stand, and the third kept in motion by clockwork. The photographs so obtained give information concerning the real course of the flashes and their duration. A couple of stereoscopic views are reproduced, which show that the lightning flash consisted of two spatially separate discharges. E. E. F.

657. *Atmospheric Electrification during South African Dust Storms.* W. A. D. Rudge. (Nature, 91. pp. 81–82, March 18, 1918.)—The author has made observations of the potential gradient during dust storms and found that very extraordinary variations are caused by the presence of dust in the atmosphere. The dust was either sand or of a siliceous nature. Continuous records have been taken at Bloemfontein during 6 months, and typical records are reproduced showing (1) a normal fine weather record, (2) a mild dust storm, and (3) a severe dust storm. In (1) the potential gradient is positive during the 24 hours with two well-defined maxima of about 850 volts/m., in (2) these maxima are obliterated and the gradient is slight throughout the day, and in (3) large negative values prevail during the time of the dust storm. The article concludes with a description of an electrical machine which, if exposed during a dust storm, will give sparks up to 1.5 cm. in length. The action of the machine depends upon the sand being positively electrified. J. S. DI.

658. Atmospheric Electricity. G. C. Simpson. (Phys. Zeitschr. 14. pp. 41-45, Jan. 1, 1918.)—Describes some portable instruments for measuring atmospheric electricity, designed for use in the most widely varying climates. For strong insulators the author uses small cylindrical tin boxes, into which sulphur is poured round a stout brass wire. A perforated lid, not touching the wire, is slipped over the open end to keep the sulphur clean. As a collector he uses a wire drawn horizontally some distance from the ground between two uprights. To this he attaches in the centre a length of cotton twine soaked in a solution of nitre and dried. The battery recommended consists of modified Daniell cells. A stout test-tube holds two narrow tubes containing respectively the zinc rod in ZnSO_4 and the copper rod in CuSO_4 . These tubes are drawn out to capillaries below, and open into a space filled with Fuller's earth soaked in ZnSO_4 . This space also contains a few pieces of free Zn wire to absorb any stray CuSO_4 which may penetrate into it. The opening at the top is covered over with thick machine oil. A battery of 100 such cells has been in unimpaired use at Simla for 8 years. To charge an electroscope, the author uses a small ebonite rod working in a tube filled with flannel. When electrified the rod pushes against a spring into a small brass tube, to which the charge is thus communicated. E. E. F.

DISCHARGE AND OSCILLATIONS.

659. Ionisation Voltages in Gases. J. Franck and G. Hertz. (Deutsch. Phys. Gesell., Verh. 15. 2. pp. 84-44, Jan. 80, 1918.)—By Lenard's method the voltages needed for ionisation were measured for various pure gases, the results being as follows :—

Gas	He	Ne	A	H	O	N
Volts	20.5	16	12	11	9	7.5

[See Abstracts Nos. 848 (1908), 552, and 907 (1912).]

E. H. B.

660. Conductivity of Rarefied Gas affected by Magnetic Fields. H. Stasano. (Comptes Rendus, 155. pp. 911-914, Nov. 4, 1912.)—Describes experiments which show that the discharge in a vacuum tube is facilitated at times by a magnetic field whose strength must be graduated to suit the degree of rarefaction in use. [See Abstract No. 2027 (1902).] E. H. B.

661. Hertz-Hallwachs Effect. G. Reboul. (Le Radium, 9. pp. 400-404, Nov., 1912.)—A plate of copper is slowly lowered vertically into a vessel filled with bromine vapour. The deposit of bromide arranges itself in a narrow wedge showing interference colours, from which its thickness can be computed. A slit illuminated by a mercury lamp is focussed on the plate, the image being parallel to the colour-fringes. Whereas in former experiments [Abstracts Nos. 671, 1418 (1912)] the photoelectric emission varied slowly with the thickness, a displacement from one fringe to another of a freshly prepared plate shows maxima and minima of emission corresponding to maxima and minima of absorption of ultra-violet light. These are reversed by fatigue. E. E. F.

662. Production of Ozone by Lenard Rays. F. Krüger. (Phys. Zeitschr. 18. pp. 1040-1048, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—In the experiments kathode rays emerged from a kathode-ray tube through an Al window and produced ionisation in

a chamber containing either pure oxygen or pure nitrogen. With a given intensity of radiation the following were determined: (1) Ionisation in oxygen, (2) number of molecules of ozone produced per sec., (3) ionisation in nitrogen. The estimation of the ozone was determined by the absorption of the ultra-violet line $\lambda = 254 \mu\mu$ from a mercury lamp. The results with different intensities of radiation are given in the following table:—

Experiment Number.	Number of Ions produced per second.		Number of Molecules of Ozone.
	In Oxygen.	In Nitrogen.	
1	0.70×10^{14}	6.0×10^{14}	7.0×10^{14}
2	0.61×10^{14}	1.9×10^{14}	2.0×10^{14}
3	0.56×10^{14}	1.2×10^{14}	1.1×10^{14}
4	0.45×10^{14}	1.4×10^{14}	1.4×10^{14}
5	0.21×10^{14}	0.5×10^{14}	0.83×10^{14}

A correction was applied for the decay of the ozone due to the proximity of metal surfaces. The results show that the number of ozone molecules produced is in excess of the number of ions produced in oxygen and approximates more nearly to the number of ions produced in nitrogen under the same conditions.

E. M.

663. Kathode Rays. S. Rudberg. (Ark. för Mat., Astron. och Fysik, Stockholm, 8. 8. pp. 1-16, 1912.)—Answers in the affirmative, distinctly, the question whether the absorption coefficient of kathode rays passed through metallic laminæ depends on the material of the kathode; but the subject needs further investigation to ascertain the law of the relation. Kathode rays from a heavier metal are more penetrative than those from a lighter metal even though the voltage used be considerably smaller; and the heavier the metal of the kathode the more nearly does the penetrating power approach that of the β -rays. This seems to indicate that the particles shot off are proper metallic ions, and that the particles in the β -rays may also be of the same character.

A. D.

664. Dielectric Cohesion. E. Bouty. (Comptes Rendus, 155. pp. 1207-1208, Dec. 9, 1912.)—Describes a method of ascertaining the dielectric cohesion with very small quantities of a gas by observing the value of external field necessary to produce a visible glow in the gas contained in a small (8-cm.) bulb.

A. D.

665. Righi's Luminous Masses. L. Amaduzzi. (Phys. Zeitschr. 18. pp. 1202-1206, Dec. 15, 1912.)—Studies the luminous masses obtained in vacuum tubes with alternating discharges, as described by Righi in 1891 and 1895 [see also Abstract No. 912 (1912)]. The alternating-current ions were obtained by working an induction coil of 50 cm. spark length from an a.c. supply of 42 \sim at 110 volts. On reducing the pressure from atmospheric to a few mm. of Hg the brushes at the electrodes lengthened out and a uniform feeble reddish glow filled the whole length (1.4 m.) of the tube. At 14 mm. Hg reddish-violet masses about 15 cm. long appeared. These merge into one streak at 10 mm. pressure. At a given pressure they have a fixed length, so that their number varies as the length of the tube. Their number can,

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however, be reduced by increasing the inductance in the circuit. The masses are split in the middle by a slanting division in a magnetic field. Their alternating shapes are best separated by a revolving mirror. E. E. F.

666. Electric Loss in a Plane-Sphere System in Air. A. Guillet and M. Aubert. (Comptes Rendus, 156. pp. 458-460, Feb. 10, 1918.)—When the electrodes are dissimilar the phenomena differ depending on which is the positive electrode. In the present note the results of experiments on a system composed of a plane and a sphere are given. From the electrometer readings we deduce at any instant the potentials of the electrodes, their charge, and the apparent value of the leakage current. The sphere being connected with the earth and the plane insulated, the latter is electrified by means of a proof plane. The sphere approaches the plane until its centre attains a certain definite minimum position from it which the authors call a *position d'arrêt*. The ratio of the potential V of the plane to this distance d is found to be different, depending on whether the plane is positively or negatively electrified. It is found that if V_p and V_n be the positive and negative potentials at the neutral point for the same initial distance between the plane and the sphere, then V_n/V_p is a constant and equals 1.258 very approximately. This ratio the authors call the "coefficient of dissymmetry" of the system. A. R.

667. End Correction to Rods in Electrical Problems. Rayleigh. (Phil. Mag. 25. pp. 1-9, Jan., 1918.)—In a previous paper [see Abstract No. 2656 (1904)] the author endeavoured to show that the difference between the half wave-length of the gravest vibration and the length (l) of the rod (of uniform section) tends to vanish relatively when the section is reduced without limit, in opposition to the theory of Macdonald which makes $\lambda = 2.58 l$. Understanding that the argument there put forward is not considered conclusive, the author has tried to treat the question more rigorously, but the difficulties in the way are rather formidable. And this is not surprising in view of the discontinuities presented at the edges where the flat ends meet the cylindrical surface. The problem assumes a shape simpler in some respects if we suppose that the rod of length l and radius a is surrounded by a cylindrical co-axial conducting case of radius b extending to infinity in both directions. One advantage is that the vibrations are now *permanently maintained*, for no waves can escape to infinity along the tunnel, seeing that l is supposed great compared with b . The greatness of l secures also the independence of its two ends, so that the whole correction to the length, whatever it is, may be regarded as simply the double of that due to the end of a rod infinitely long. The analysis then follows and shows that, in any case, the correction δl to the length of the rod vanishes in the electrostatical problem when the radius of the rod is diminished without limit, a conclusion which the author extends to the vibrational problem specified in the earlier portion of this paper. E. H. B.

668. Complete Solution of the Differential Equations of two Magnetically Coupled Oscillatory Circuits of Constant Damping. F. Kiebitz. (Ann. d. Physik, 40. 1. pp. 188-166, Dec. 31, 1912.)

669. Theory of Photoelectric Current in Gases. A. Partzsch. (Ann. d. Physik, 40. 1. pp. 157-198, Dec. 31, 1912. Abbreviation from Dissertation, Rostock.)—[See Abstract No. 552 (1912).]

670. Stroboscopic Effects obtained with Incandescent Filaments as Illuminants. C. F. Lorenz. (Electrical World, 60. pp. 1146-1148, Nov. 30, 1912.)—An account of some experiments with incandescent (tungsten) filaments immersed in an inert cooling gas (ammonia). The original pages should be referred to. L. H. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

671. Resistance of Solid and of Liquid Mercury. A. Baltruszajtis. (Acad. Sci. Cracovie, Bull. 9a. pp. 888-898, Nov., 1912.)—The ratio of the specific resistance of solid mercury to that of liquid mercury, both being at the freezing-point of mercury, was found to be 4.90. The resistance of solid mercury was measured at as high a temperature as -88.91° and that of liquid mercury at as low a temperature as -88.11° . The resistance of solid mercury is very approximately a linear function of the temperature. F. E. S.

672. Measurement of High Resistances. Tournier. (Comptes Rendus, 155. pp. 1242-1248, Dec. 9, 1912.)—A description of a modification of the potentiometer method of comparing resistances; a quadrant electrometer being used with alternating currents so that the method is applicable to electrolytes. J. J. S.

673. Resistance of Metallo-crystalline Junctions. A. Wesely. (Phys. Zeitschr. 14. pp. 76-81, Jan. 15, 1913.)—Measures the resistance of crystals of galena, pyrites, and markasite between electrodes of amalgamated lead at various pressures, and between Hg terminals at various temperatures. That of a cm.-cube of galena was 0.06596 ohm under moderate pressure, which could be reduced to 0.00142 ohm by screw compression. The amount of pressure was not determined. The change of resistance with temperature, which is always non-metallic, is well expressed by Koenigsberger's equation. But at higher temperatures highly resisting transition layers are easily formed. E. E. F.

674. Artificial Metallic Conductors. K. Baedeker. (Phys. Zeitschr. 18. pp. 1080-1082; Discussion, p. 1082, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—Cuprous iodide has the property of absorbing iodine in the solid state and thus acquiring electrical conductivity. Every gramme of CuI can absorb 8.8 mgm. of iodine, and thus acquires a conductivity which amounts to 100 times that of sulphuric acid of max. conductivity. A feeble action of the same kind is found in AgI. The iodides are not decomposed by the current, and fit into the Volta series. CuI preparations of high conductivity have the ordinary metallic temperature-coefficient. The Hall-effect in these preparations is directly proportional to the resistance, at least in the specimens of medium conductivity. The thermoelectric force between two specimens of different conductivities is theoretically $= (R/F) \log_e (n_1/n_2)$, where $R = 8.816 \times 10^7$, $F = 9647$, and n_1, n_2 are the electron concentrations. This can be put $= 198.5 \log_{10} (W_2/W_1)$ microvolt-degrees, where W_2, W_1 are the resistances. This formula is closely rendered by the observed values. In the discussion, Glatzel proposed to use CuI to construct photoelectric cells free from inertia. Nernst pointed out that the validity of the gas laws was assumed for electrons, which involved certain difficulties. E. E. F.

675. *The Silver Voltameter.* E. B. Rosa, G. W. Vinal, and A. S. McDaniel. (Electrical World, 61. pp. 84-85, Jan. 11, 1918).—[See also Abstract No. 501 (1918).] The small porous-cup voltameter was found to be most convenient and reliable to use as a standard. As a test of the reproducibility of this form, there were tabulated 54 deposits, made in pairs (with 2 exceptions), and the average deviation of each value from the mean of each group of two or three cups was found to be 1 part in 100,000. The mean value led to the value 1.01827 int. volts at 20° C. being assigned to the Weston normal cell. Comparison of the large porous-cup voltameter with the smaller size showed consistently a heavier deposit in the former by about 5 parts in 100,000, and the siphon form, which required a very large volume of electrolyte, gave a still greater excess. This excess of deposit in the larger sizes of voltameter was roughly proportional to the volume of electrolyte and the authors have called this the "volume effect." Eventually, electrolyte was prepared which satisfied all the criteria for purity and brought all the sizes of voltameters into agreement. With regard to chemical tests for purity of the electrolyte, iodeosine was used as an indicator and by means of it 1 part in 1,000,000 of acid or alkali could be detected. For the detection of reducing impurities, a titration test with (N/1000) KMnO_4 solution has proved very valuable. The authors give particulars of methods for purifying AgNO_3 and also state that experiments made by them indicate that there is no temperature coefficient to the silver voltameter. F. E. S.

676. *Effect of Light-radiation on a Telephone.* O. Grottrian. (Ann. d. Physik, 89. 6. pp. 1625-1682, Dec. 28, 1912).—When light is allowed to fall on the plate of a telephone receiver, a momentary current is induced in the coil of the receiver. To investigate the effect, light from an arc lamp is thrown on the plate after passing through various filters. As the heat waves are cut out, the effect becomes very small. There is, however, still a perceptible effect with ultra-violet rays. T. P. B.

677. *An Electric Constriction Experiment.* E. F. Northrup. (Metallurgical and Chem. Engin. 11. p. 48, Jan., 1918).—A wooden trough is filled with mercury, and a piece of sheet copper floated on the mercury; electrodes are inserted into the mercury at the ends of the trough. The copper has the shape of a sector, one end pointed, the other rounded. When current from a 12-volt battery is turned on, the copper float moves with its rounded end forward, because copper conducts much better than mercury, and the streamlines are concentrated at the sharp point. When the float is held stationary, the mercury becomes agitated. An amperemeter has been based upon this observation. H. B.

678. *Determination of Capacity of Coils.* W. Hüter. (Ann. d. Physik, 89. 6. pp. 1850-1880, Dec. 28, 1912. Extract from Dissertation, Munich, 1911.)—Single-layer coils of copper wire wound bifilarly are used. The frequency n employed in the determinations was 480 per sec. It is shown that with the low self-induction (L) and capacity (C) employed, the resistance-operator (R) of the coil is equal to $r(1 + i2\pi n\phi)$, r being the continuous-current resistance of the coil, and ϕ , the phase-factor, being equal to $L/r - rC$. ϕ is determined by a Wheatstone bridge method. L and C are separated by determining ϕ with the coil at different temperatures. T. P. B.

679. *Electrical Disintegration of Metals and its Possible Use as a Method of Testing.* C. Benedicks. (Rev. de Métallurgie, 9. pp. 1094-1102, Dec., 1912.) VOL. XVI.—A.—1913.

—The method of electrical disintegration used by Svedberg in colloidal synthesis has been studied with a view to its application to the testing of metals. After the passage of a spark from a Ruhmkorff coil and Leyden jar between electrodes of metals immersed in ether, numerous small craters appear on the surface. One crater is considerably larger than the others and evidently corresponds to the pilot spark, while the smaller ones correspond to subsequent oscillatory discharges. Comparison with the craters of fusion produced by impinging a fine jet of hot air on asphalt, shows that the craters are true centres of fusion due to the voltaic arc caused by the passing spark. At the same time particles of molten metal are projected mechanically. That there is considerable mechanical energy developed is shown by the fact that unless the electrodes are tightly clamped they are forced apart during the passage of the spark. From these facts it is fairly obvious that the disintegration is brought about thermodynamically, the essential factors being the total heat of fusion and the thermal conductivity of the material, while the total heat of vaporisation, the viscosity, and superficial tension of the molten metal play minor parts. A series of determinations made on eutectic alloys with low total heats of fusion gives low rates of disintegration, showing that the viscosity of molten alloys is greater than that of the pure metals. The size of the craters (about 0.15 mm. in diam.) renders the method a macroscopic rather than a microscopic one. It provides the only known method of removing from a plane metallic surface, the most fusible constituent or the constituent having a thermal conductivity lower than that of the ground-mass. Examination of a series of steels shows that the size of the craters increases with the content of carbon. Cementite-rich and slag-rich areas are shown very distinctly by this method which is an admirable way of rendering lack of homogeneity visible to the naked eye.

F. C. A. H. L.

680. Effective Capacity of Quadrant Electrometer when used as Quantometer. R. Beattie. (*Electrician*, 70, pp. 683–685, Jan. 10, 1918.)—If C is the capacity of the electrometer and V the potential of the needle, the latter is subject to a resultant controlling couple due to the action of (i) a mechanical control $k_1\theta$, (ii) a distortional electrostatic control $k_2V^2\theta$, and (iii) an inductional electrostatic control $k_3V^2\theta/C$, k_1 , k_2 , and k_3 being instrumental constants. The deflection θ of the needle varies as $qV/(C + k_2V^2C/k_1 + k_3V^2/k_1)$. The denominator can be put in the form $C + k_2V^2/(k_1 + k_3V^2)$, which is regarded as the effective or dynamical capacity of the instrument. Under certain conditions, the distortional control may become negative and equal to the mechanical control. With inductional control alone, the needle moves just far enough to make the charge induced on the isolated quadrants exactly equal to the externally communicated charge. The action of an electrometer so adjusted may be compared with that of an electromagnetic quantometer or fluxmeter, where, in the absence of mechanical control, the moving coil rotates just so far as to make the quantity induced in the circuit equal to the quantity sent through it from outside sources.

G. E. A.

681. New Scheme of Connections for Spark-coil Interrupters. W. Burstyn. (*Elektrotechn. Zeitschr.* 88, p. 1109, Oct. 24, 1912.)—Owing to the difficulty experienced in working spark coils with hammer interrupters off the supply voltage and the heavy strain on the contacts if ordinary resistance is put in series, the author has devised a method which, it is claimed, does away with these difficulties. The arrangement consists, firstly, in inserting a very high series resistance; secondly, in providing an interrupting key (normally open)

in the make-and-break circuit (normally closed) and a condenser of about 1 mfd. capacity in the interrupter magnet circuit which is in parallel with the former circuit. The supply current charges the condenser through the interrupter magnet winding, and on closing the key the condenser discharges through the magnet winding, in the form of a somewhat damped oscillating current. The magnetic impulse imparted attracts the armature and opens the "break" contact, so that condenser is again able to charge itself. On the break contact closing again, on the return swing of the spring, the condenser again discharges itself, and so on, as long as the key is held down. The contact has in this way only to deal with the small non-inductive current passing through the series high resistance. Diagrams are given of the arrangement and of the circuit as applied to spark coils, for which latter purpose another condenser should be inserted in series with the interrupter. The arrangement forms the subject matter of a German Patent application.

L. H. W.

682. *Thermoelectric Couples.* G. Meslin. (Comptes Rendus, 155. pp. 906-908, Nov. 4, 1912.)—In calculating the magnitude of the Thomson-effect and determining what portion of the e.m.f. is due, in the case of particular couples, to the Thomson- and what to the Peltier-effect a graphical method may be used. This method is available in all cases where the e.m.f. may be represented by the formula $E = m(T_1 - T_2)[T_0 - (T_1 + T_2)/2] \dots (1)$. It consists in drawing a parabola such that from its dimensions the values of e.m.f., Peltier-, and Thomson-effects may be deduced. This parabola, $Y = mT(T_0 - T/2)$, where Y and T are the two co-ordinates, may be used for all couples which may be represented by formula (1); it is only necessary to *reduce* suitably the equation for the particular case required which has its own particular values for the constants m and T_0 . So that it may be enunciated that : (a) For corresponding temperatures the e.m.f. are corresponding ; and (b) at corresponding temperatures, the thermoelectric powers are corresponding, as well as the values of the Peltier- and Thomson-effects. These theorems result from the fact that formula (1) contains only two constants. Hence a table may be drawn up, to facilitate calculations, of the e.m.f. and the part due to the Peltier- and Thomson-effects in different cases. The present paper contains a diagram of the parabolas mentioned and the full paper to be published elsewhere gives a table such as that referred to. J. J. S.

683. *Thermal E.M.F. of Tungsten and Molybdenum.* E. F. Northrup. (Metallurgical and Chem. Engin. 11. p. 45, Jan., 1918.)—Although tungsten and molybdenum oxidise at high temperatures the author has been able to obtain the temperature-e.m.f. curve of a thermo-couple composed of these two metals. In the experiments, temperatures were measured by means of a Pt and Pt-Rh thermo-couple. For the range 0—1000° C. the e.m.f. was found to be given in microvolts by $E = 4.61t - 0.00438t^2$ and when the cold junction is at 0° C., the e.m.f. is a maximum at 580° C. and is zero at 1060° C. In this range the current flows from W to Mo at the hot junction. The author suggests that, if all samples are found to behave in the same way, the neutral point would be a convenient method of fixing the temperature, 1060° C. He thinks that it is quite likely that a case will be found for protecting the couple against oxidation at high temperatures (such as 2000° C.). W. C. S. P.

684. *Electron Theory of Thermoelectricity.* O. W. Richardson. (Phil. Mag. 24. pp. 787-744, Nov., 1912.)—The author discusses the criticisms of VOL. XVI.—A.—1918.

N. Bohr [Abstract No. 1898 (1912)] and H. A. Wilson on his former papers. The difference between Bohr's results and the author's may arise from the neglect to include effects arising from a possible difference in the rate of transference of kinetic energy by an electric current in different materials. In the present paper the previous calculations are extended to include these effects. It seems probable that effects due to chemical action ought to be included, and recent experiments by Pring and Parker on carbon and of Fredenhagen on sodium and potassium strengthen this probability. Richardson considers that electronic emission may be conditioned by chemical action, but thinks that there is considerable evidence in favour of the view that there is an emission of electrons from hot conductors which is independent of chemical action.

J. J. S.

685. Damped Moving-magnet Galvanometer. C. Féry. (Comptes Rendus, 155. pp. 1008-1010, Nov. 18, 1912.)—In moving-coil galvanometers the damping due to induced currents brought about by the motion of the magnet is insufficient. The author gives a brief description of an instrument in which the damping has been increased to its critical value by suspending the magnet with each pole between two pairs of coils which are sufficiently close to be equivalent to a solenoid. He also describes an astatic damped galvanometer which gives 1 mm. deflection at 1 m. for a current of 8×10^{-10} amp. The resistance of this instrument is only 2 ohms and it has a period of 15 secs.

W. C. S. P.

686. Improved Influence Electrical Machine. H. Wommelsdorf. (Ann. d. Physik, 89. 6. pp. 1201-1206, Dec. 28, 1912.)—The author has so perfected his influence machine [see Abstract No. 181 (1908)] that it has now been put upon the market, and he claims that in reliability and efficiency it easily surpasses all other influence machines. Tables of voltage and current strength are given to show this. As insulating material he uses ebonite covered with a film of "bakelite." The conducting parts are completely embedded in insulating material. The electricity is taken off from a slit in the edge of the rotating plates.

T. P. B.

687. Electric Furnace for Experiments in Vacuo at Temperatures up to 1500° C. R. E. Slade. (Roy. Soc., Proc. Ser. A. 87. pp. 519-524, Dec. 18, 1912.)—This furnace consists of a Pt-tube 2 cm. in diam. and 17 cm. long, with walls 1 mm. thick. This was mounted in water-cooled brass terminals at the ends. By means of a current of 850-500 amps. at 8-4 volts passed through the tube, the interior of the latter attained a temperature of 1400-1500°. The tube is fitted in an asbestos box filled with magnesia, and the whole furnace is placed under an iron dome. Arrangements are made for evacuating the furnace, for reading the internal pressure, for measuring the temperature by means of a thermo-element, etc. Diagrams and a detailed description of the apparatus are given.

T. H. P.

ALTERNATING CURRENTS AND MAGNETISM.

688. Alternate-current Circuits with Electric Valves. N. Papalex. (Ann. d. Physik, 89. 5. pp. 976-996, Dec. 5, 1912.)—Treats the behaviour of Al valves both theoretically and experimentally. The action depends largely upon the inductance and resistance of the circuit. If there is only ohmic resistance in circuit, the action of the valve consists simply in weakening the

phases in accordance with its resistance in the two directions. If there is a high inductance in circuit, the resulting current has a d.c. component and a superimposed sine component of the amplitude of the direct current. The effective current is $\sqrt{8}$ times greater than if the valve is short-circuited. The transformation ratio can be raised from some 64 per cent. to about 82 per cent. by the insertion of a suitable inductance. The dynamical characteristics of Al valves were studied by means of a Braun tube. It was found that shortly after their formation the valves are nearly perfect valves, and the theoretical deductions are confirmed. But the valves deteriorate after a short time which depends upon the constants of the circuit. E. E. F.

689. *Kinetic Theory of Magnetism*. E. Schrödinger. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1805-1828, July, 1912.)—Shows mathematically that N free electrons of the mean free path λ contained in unit volume of a body impart to it a diamagnetic susceptibility proportional to $N\lambda^2$, and to a first approximation independent of the field. In Bi the susceptibility calculated is of the order of the observed value, but in metals of greater conductivity the calculated value is much higher, unless improbably small wave-lengths are assumed. The author thinks the observed susceptibilities of feebly magnetic bodies are usually the differences between a large Langevin paramagnetism and the diamagnetism due to free electrons. This would explain the discrepancy between Honda's and Owen's temperature curves and the Curie-Langevin laws. Thus in gases, in electrolytes, and in strongly paramagnetic bodies these laws are obeyed. In gases and electrolytes, as well as insulators like P, S, SiO₂, there is no metallic conductivity, i.e. no free electrons. The author's theory demands for the susceptibility of all metallic conductors a positive term proportional to the square of the field, and this should be most perceptible at low temperatures. Thus, in copper at 20° abs. the susceptibility in the strongest fields should differ from that in weak fields by 25 per cent. E. E. F.

690. *Absolute Susceptibility of Liquids*. W. J. de Haas and P. Drapier. (Deutsch. Phys. Gesell., Verh. 15. 8. p. 92, Feb. 15, 1918.)—A continuation of research [see Abstract No. 1890 (1912)]. The value found for water at 22° in a nitrogen atmosphere was -0.726×10^{-6} , and in air -0.747×10^{-6} . A fuller account will appear in the Annalen. G. E. A.

691. *Magnetism and Molecular Structure*. E. Holm. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. 16. pp. 1-59, 1912.)—After referring to the various hypotheses as to molecular structure which have been put forward since that of Poisson to explain the process of magnetisation, the more recent development of the electron and magneton theory of Langevin and Weiss is discussed at full length. The extent to which the phenomenon of dia-, para-, or ferro-magnetism appears in a body depends only on the molecular state of that body. If the molecule or atom which carries the free magnetons is of small mass, the body exhibits diamagnetic properties. If the magnetic intensity produced by these free magnetons can overcome the diamagnetism of the bound magnetons, then paramagnetism is displayed. If, however, many carriers of free magnetons combine, so as to greatly increase the total mass of the molecule without altering the saturation intensity per unit of mass, the body exhibits ferromagnetism. If polymerisation can be effected between the molecules with free magnetons, the susceptibility of the body is increased, as in Heusler's alloy. Polymerisation between the molecules of a

body is influenced, not by its magnetic condition, but by its temperature. Within the γ region, iron exhibits progressive polymerisation, and the same phenomenon is shown by most elements within a considerable range of temperature above -180°C .
G. E. A.

692. Demagnetisation and Recovery of Permanent Magnets. S. Sano. (Electrical World, 61. pp. 96-97, Jan. 11, 1912.)—The effect upon the magnetism of a horseshoe magnet of rubbing the armature on the surface of the magnet from the poles towards the curved portion was measured by observing the throw on a ballistic galvanometer joined to a coil inserted between the poles when the coil was suddenly withdrawn. The strength of the magnet was lowered considerably by rubbing it with the armature when the magnetisation was high, but it is not so much affected after the magnetisation has been lowered. After the first stroke the magnetic force was decreased by about 25 %, while from the 88rd to the 68rd stroke the percentage throw of the galvanometer decreased only from 51.6 to 50.8. In a second experiment the keeper was caused to slide upon the side of the magnet first in one direction and then in the opposite. The first positive stroke decreased the throw of the galvanometer from 68 to 50.5, and the next negative stroke increased it to 51.5. From the sixth reading on, the recovery of magnetisation due to negative rubbing was almost complete.
J. J. S.

693. Paramagnetism at Low Temperatures. H. Kamerlingh Onnes and E. Oosterhuis. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 822-829, Oct. 24, 1912. Communication No. 129B from the Phys. Lab., Leiden.)—An account is given of the continuation of experiments discussed formerly by Onnes and Perrier. The attraction excited by a non-homogeneous field upon a long cylinder of the experimental substance was again measured. This latter was finely powdered and contained in a glass tube. The effect of the glass was eliminated, the tube being taken twice as long as the part containing the powder. Anhydrous ferrous sulphate and also a specimen not quite anhydrous were examined at room temperature and at the temperatures of liquid ethylene, liquid nitrogen, and liquid hydrogen. The deviations from Curie's law are discussed. The formula $\chi(T + \Delta') = C'$, used by Weiss and Foëx, was found to apply in general for temperatures not below -208°C . Other substances were examined, and it was found that gadolinium sulphate follows Curie's law over the whole region of low temperatures down to the lowest hydrogen temperature, 14° , and is thus a normal paramagnetic substance. Down to the lowest hydrogen temperature dysprosium oxide obeys the law $\chi(T + \Delta') = C'$, with Δ' and C' positive. Over this region of temperature it shows thus a disturbance of the first kind, due to a Weiss molecular field of opposite sign. Down to -208°C . manganese chloride is normal. At hydrogen temperatures it deviates, showing a disturbance of the first kind. Crystallised ferrous sulphate behaves similarly. Anhydrous ferrous sulphate and the sulphate not quite anhydrous show a disturbance of the first kind down to -208°C . At hydrogen temperatures they show a disturbance of the second kind (both Δ'' and C'' negative). With ferric sulphate a dependence of the susceptibility on the magnetic field was found at hydrogen temperatures, which leads to the presumption that at these temperatures there exists ferromagnetism in a substance which at ordinary temperatures is paramagnetic. Further results are to be given in a subsequent paper.
J. J. S.

694. Hall-effect and Change in Resistance in a Magnetic Field at Low Temperatures. H. Kamerlingh Onnes and B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 807-818, Oct. 24, 1912. Communication No. 129A from the Phys. Lab., Leiden.)—An investigation of the Hall-effect and the change in resistance produced by a magnetic field was carried out at temperatures down to the boiling-point of hydrogen and at lower temperatures. Experiments were made first with a wire of electrolytic Bi to test its change of resistance; the change in different fields was similar to that found with liquid air. The results with plates of compressed electrolytic Bi as to Hall-effect and increase of resistance are given in a series of tables. With one disc the Hall-coefficient (R) approached a limiting value 100, the highest yet obtained for Bi. The value increases with the field (H). All the coefficients obtained for Bi plates are *negative*. The value of R for other metals was also investigated, and at hydrogen temperatures was as follows :—

T.	Au _H .	Ag _H .	Cu _H .	Pd _H .
29.0°	7.24×10^{-4}	8.00×10^{-4}	4.92×10^{-4}	6.75×10^{-4}
20.8	9.81×10^{-4}	10.14×10^{-4}	6.62×10^{-4}	18.68×10^{-4}
14.5	9.82×10^{-4}	9.91×10^{-4}	6.56×10^{-4}	18.85×10^{-4}

The change in the Hall-coefficient for Ag and Au takes place chiefly below -190° C., and becomes practically constant again in the region of liquid hydrogen temperatures. While at ordinary temperatures the change caused in the resistance of these metals by the magnetic field is extremely small, at hydrogen temperatures it becomes quite appreciable. The Hall-effect was observed in a Bi crystal with the axis perpendicular to the field. At hydrogen temperatures R is positive and approximates to a constant value; at ordinary temperature it is RH, corresponding to negative values of R, which approaches a constant value. [See next Abstract.] J. J. S.

695. Hall-effect and Change in Resistance in a Magnetic Field at Low Temperatures. H. Kamerlingh Onnes and B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 819-821, Oct. 24, 1912. Communication No. 129c from the Phys. Lab., Leiden.)—This is a continuation of the account of experiments on Bi at and below the boiling-point of hydrogen. As suggested by J. Becquerel [Abstract No. 1448 (1912)], the fact that the Hall-effect for Bi in strong fields can be represented by a linear function of the field strength may be regarded as resulting from the composition of the effect from two separate components. One of these is proportional to the field, and was found by the authors to be always negative for plates of compressed electrolytic Bi. The second approaches a limiting value and was found to be constant at hydrogen temperatures in fields greater than 8 kilogauss. That is, the law of linear dependence upon the field is obeyed by the first component of Becquerel in fields greater than 8 kilogauss. Referring to the equation $RH = a'H + b'$, on going down to liquid-hydrogen temperatures the constant b' , the max. value of the second Becquerel component, which is negative at ordinary temperatures, becomes positive in the case of plates Bi_H and Bi_{pm}. At hydrogen temperatures the sign of the Hall-effect reverses and becomes positive, increasing linearly with the field for fields above

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8 kilogauss. The authors find for crystals with axis perpendicular to the field a result analogous to that got by Becquerel with the axis parallel to the field. [See next Abstract.] J. J. S.

696. Hall-effect and Change in Resistance in a Magnetic Field at Low Temperatures. B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 649-659, Nov. 28, 1912. Communication No. 180A from the Phys. Lab., Leiden.)—A continuation of previous accounts of researches [see two preceding Abstracts], the results being extended to the temperatures obtainable with liquid ethylene and liquid oxygen. The results obtained with Bi are discussed in the present communication and are given in a series of tables and curves. The change in the resistance of Bi was observed in eight different fields and at five different temperatures: 290° , 170° , 189.5° , 90° , and 72° abs. In the weaker fields the isotherms (showing increase of resistance as a function of the field at constant temperature) are convex towards the axis of abscissæ; from 12 kilogauss upwards they become straight. For $H > 12,000$ the relation $w'/w = aH + b$ holds, where w' = resistance in the magnetic field and w = resistance without field and a and b are constants. At lower temperatures $a = a_0 e^{-\beta T}$ to a first approximation. The behaviour as regards the Hall-effect varies in the case of different specimens of Bi. The results in certain experiments indicate the presence of impurity in the bismuth. At $T = 289^{\circ}$ the specific resistance of specimen Bi_{μ} is about 1.5×10^6 and for Bi_{μ} 2.8×10^6 C.G.S. The magnetic change of resistance is much smaller for Bi_{μ} particularly at low temperatures. Just as in the experiments in liquid hydrogen, for $H > 8000$, RH becomes a linear function of the field $RH = a'H + b'$. Following J. Becquerel the Hall-effect may be regarded as resulting from two components: one proportional to the field and always negative for the plates used; the other constant (or saturated) for these plates (Bi_{μ} , Bi_{μ}) from $H = 8000$ upwards. In strong fields the constant R approaches a limiting value. In weak fields RH for Bi_{μ} is inversely proportional to the temperature at $T = 289^{\circ}$, 90° , 74.5° abs. [See next Abstract.]

J. J. S.

697. Hall-effect and Change in Resistance in a Magnetic Field at Low Temperatures. B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 659-668, Nov. 28, 1912. Communication No. 180B from the Phys. Lab., Leiden.)—This paper is a continuation of that dealt with in the preceding Abstract, and discusses the Hall-effect in the case of Au, Ag, Cu, and Pd at temperatures between $+17^{\circ}$ C. and -200° C., and also the behaviour of gold-silver alloys. From the observations made it appears that the Hall-coefficient for Au, Ag, and Pd is almost constant from ordinary temperatures down to that of liquid air. A distinct increase is noticed on proceeding to hydrogen temperatures which amounts to 25-35 % for Au, Ag, and Ca, and 100 % in the case of Pd. For an alloy of Au-Ag containing 2 % Ag by volume the Hall-coefficient was found to be almost constant. On proceeding to low temperatures it begins to show a slight decrease.

J. J. S.

698. Hall-effect for Alloys at the Boiling-point of Hydrogen and at Lower Temperatures. H. Kamerlingh Onnes and B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 664-666, Nov. 28, 1912. Communication No. 180C from the Phys. Lab., Leiden.)—Measurements on two Au-Ag alloys containing greater percentages of silver than in the case described in the preceding Abstract are described. One alloy contained

10.6 atom. per cent. of silver. The thickness of the plate was 0.049 mm., and the Hall-effect was measured at temperatures 290°, 20.8°, and 14.5° abs. The ratio of the resistance without field at the temperatures mentioned to the resistance at 0° C. without field is at the three temperatures 1.08, 0.585, and 0.58. The Hall-coefficient R changes with the percentage of silver in the alloy. $R_{T=20}/R_{T=290}$ diminishes for greater percentages of Ag. For pure gold $R_{T=20.8} > R_{T=290}$, but for alloys with more than 2 % Ag by volume $R_{T=20.8} < R_{T=290}$. The curve that represents the relation between the Hall-coefficient $R_{T=20.8}$ and the percentage of silver is of a shape analogous to that representing the conductivity or the temperature coefficient of the resistance as a function of percentages of Ag. The curve for $R_{T=20.8}$ at first descends very rapidly for small admixtures of Ag; at higher concentrations it becomes flatter. The Hall-coefficient $R_{T=20.8}$ is approximately a linear function of the quantity $W_{T=20.8}/W_{T=278}$ for alloys with less than about 8 % by volume of Ag. The Hall-coefficient $R_{T=290}$ diminishes also though much more slowly than $R_{T=20.8}$ when the percentage of Ag increases. J. J. S.

699. *Susceptibility of Iron, Steel, Nickel, and Cobalt at High Temperatures.* K. Honda and H. Takagi. (Mathematico-Physical Soc., Tōkyō, Proc. 6. 22. pp. 814-825, Dec., 1912.)—In view of the importance, for the magneton theory, of the susceptibility of ferromagnetic substances at high temperatures, the testing of these was repeated to find whether the inverse proportionality of susceptibility to absolute temperature was exact. The Curie method was employed as on a former occasion, tests being carried out up to 1800° C. For nickel, the Curie law holds throughout a wide range of temperature, but deviations from the law were observed below 500° C. No discontinuity in the $1/\chi - t$ curve was noted at 900°. The law does not hold so well in cobalt as in nickel. Below 1240° the $1/\chi - t$ curve is convex to the temperature axis, but straight at higher temperatures. The law is only approximate for β iron and for steel with 14 per cent. of carbon when in the β state; it does not hold at all for γ iron or for steel in the γ region. With steel in the β region, increase of carbon causes increase of deviation from the Curie law. [See also Abstracts Nos. 581 (1911), 1111 (1912), 516 (1918).] G. E. A.

700. *Polar Armatures.* H. du Bois. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 880-886, Oct. 24, 1912. Communication from the Bosscha Laboratory.)—The field due to ferromagnetic pole-pieces is only known for particular points in a few special cases: the author has therefore developed a more general and complete theory for arbitrary points in the field, regard being paid also to protruding frontal surfaces. Equations for prismatic pole-pieces as well as truncated cones have been calculated and the formulæ for round and prismatic armatures in special cases are discussed. J. J. S.

701. *Sun-spots and Terrestrial Magnetic Phenomena.* A. L. Cortie. (Roy. Astronom. Soc., M.N. 73. pp. 52-60, Nov., 1912.)—From an examination of the data for the period 1898-1911 it is shown that the cause of the inequality in frequency of magnetic disturbances is the inclination of the sun's axis to the plane of the equator, and the position of the earth relative to the sun-spot zones. It is also found that the magnetic storms in the period under discussion were more prolific in those years in which the mean daily area of spots was greater in the southern than in the northern hemisphere of the sun. C. P. B.

702. Measurements of Terrestrial Magnetism, Atmospheric Electricity, and Light Intensity during the Solar Eclipse of April 17, 1912. **W. Kolhörster.** (Deutsch. Phys. Gesell., Verh. 14. 16. pp. 812-826, Aug. 80, 1912.)—The observations were made at the Physical Institute of Halle in Saxony. The magnetic records for the 17th when compared with those for the 16th and the 18th show that the declination was slightly lower than usual during the eclipse, while before and after the eclipse it was normal. The horizontal force was slightly higher during the time of eclipse than on the 16th and 18th. The observed values of electrical dissipation were lower during the eclipse than before and after it, and also lower than on the 16th and 18th, but the difference is not sufficiently great to allow any direct influence to be traced. Measurements of the sun's brightness were made electrically. The graph showing the results exhibits a gradual fall from the commencement of the eclipse to the time of max. phase when only 3.65 per cent. of the original brightness was recorded.
R. C

703. Theory of Magnetism. **H. A. Lorentz.** (Archives Musée Teyler, 1. Ser. 8. pp. 75-86, 1912.)—A short review of the present state of the electronic theory of magnetism in which the chief conclusions arrived at, from the consideration of the work of Curie, Langevin, Weiss, and others, are set forth.
G. E. A.

704. Molecular Magnetism. **P. Weiss.** (Archives des Science, 84. pp. 197-215, Sept., 1912.)—A popular account of the magneton theory. [See Abstract No. 222 (1912).]

705. Mutual Action of Two Magnets placed in any Position. **A. Schmidt.** Terrestrial Magnetism, 17. pp. 181-282, Dec., 1912.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

706. Chemical Reactions of β -Gold and Crystalline Gold. M. Hanriot and F. Raoult. (Comptes Rendus, 155. pp. 1086-1088, Nov. 25, 1912.)—Brown gold [Abstracts Nos. 551 and 968 (1911)] is much more soluble than ordinary yellow gold in nitric and hydrochloric acids, the solubility in the latter being much greater in an atmosphere of oxygen than in CO_2 . Brown gold is slightly soluble in AuCl_3 , and very much more soluble in hot AuCl_3 containing 25 per cent. of HCl gas. Such a solution, on cooling, deposits crystals of gold, which from their magnetic susceptibility evidently consist entirely of β -gold. Hence solution in hot AuCl_3 containing HCl gas is a means of separating the α and β varieties of brown gold. W. H. St.

707. Active Nitrogen. F. Comte. (Phys. Zeitschr. 14. pp. 74-76, Jan. 15, 1913.)—Quotes some experiments which go to show that "chemically active nitrogen" [Abstracts Nos. 98 (1906), 1897 (1912)] requires for its manifestation the presence of a trace of oxygen. On passing commercial compressed nitrogen successively through water, soda-lime, calcium chloride, hot copper dust, and phosphorus pentoxide the cloudy luminiscence described by Strutt appeared at first under the influence of an electric discharge, but gradually decreased, ceasing after the nitrogen had been passed for 8 to 4 hours. On mixing a little air with the nitrogen the luminosity returned. The amount of oxygen required was too small to be determined. E. E. F.

708. Radio-active Elements and the Periodic System. A. van den Broek. (Phys. Zeitschr. 14. pp. 32-41, Jan. 1, 1913.)—Since it is found that no radio-active element emits more than one α -particle, and that several of them (U, RaC, and ThB) can give rise to two subsequent series, the number of products to be arranged in the periodic system is 14 for the Ra and Th families, and 5 for the Ac family. No products are considered to be separate elements unless they have different atom weights, the expulsion of β -particles not constituting a transmutation. Out of the 14, the 5 descendants of Ra and Th emanations may be placed in groups 6, 7, and 8. For the two emanations, for radiothorium, and ionium, however, we must assume that they form a complex group, like group 8 generally. Then the mean successive difference in atomic weight becomes 2 for the whole system, and the intra-atomic charge is half the atomic weight. With every step the valency increases by one unit, and when the valency reaches 8 the valency bonds are probably arranged in a tetrahedral or cubical manner, with successive concentric shells for the higher series. E. E. F.

709. Valency of the Radio-active Elements. G. v. Hevesy. (Phys. Zeitschr. 14. pp. 49-62, Jan. 15, 1913.)—The valency was determined by observing the velocity of diffusion of kathions in a large excess of their anions, the constant of diffusion being $1.25/n$ cm.²/day, when n is the valency. The method was that of Graham and Stephan, and the apparatus resembled Scheffer's. RaCl_2 , diffusing into $0.01 \cdot n\text{HCl}$, gave a valency of 2. Uranium I. and Ur II. are sexavalent, UrX , ionium, thorium, radiothorium, and

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radioactinium are quadrivalent; the emanations have no valency, and the remaining elements are univalent or bivalent. The method was controlled by a determination of the mobility of the same ions, and Nernst's formula for the diffusion coefficient $D_{18} = 0.04485/n \cdot u/v(u+v)$ was confirmed for all valencies. The connection between the mobility of the ion and its position in the periodic system indicates that ThB, RaB, and AcB give univalent ions in solutions, but are not alkali metals, and should be placed between Pb and Tl. It appears that an expulsion of an α -particle changes the valency by two units, and makes the ion more electro-positive. The contrary change is produced by the expulsion of β -particles. The expulsion of α -particles is similar in its effects to the reduction in the valency of a multi-valent metallic kathion. This also enhances the electro-positive character of the element.

E. E. F.

710. *Sodium as a Member of a Radio-active Series.* F. C. Brown. (Le Radium, 9. pp. 352-355, Oct., 1912. Science, 87. pp. 72-75, Jan. 10, 1918.)—Sodium is generally considered as non-radio-active, since no observers have been able to detect any ionising radiation from it. In the present paper, however, the author advances the view that there is evidence of its radio-active nature from geological considerations. Assuming that the salinity of the ocean is due to the salt taken to it by the water of rivers, Joly has calculated the age of the earth to be about 7×10^7 years. From the He-, Pb-, and Ur-content of rocks, however, a minimum estimate of about 6 times this period is obtained. Accepting the latter estimate, it follows either that there is too little NaCl in the ocean, or too much in water of rivers at the present time. The author advances the supposition that the NaCl-content of rivers is high because sodium is being produced by disintegration of some substance present on the land only. Evidence in support of this idea is also presumed from the fact that river waters contain a large excess of sodium relative to chlorine, while in the ocean the reverse holds.

E. M.

711. *Heating Effect of Radium.* V. F. Hess. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1419-1427, July, 1912. Communication from the Inst. f. Radiumforschung.)—The author has made measurements, using the radium purified by Hönigschmid and the apparatus of Meyer and Hess [Abstract No. 546 (1912)]. The radium salt, 570.10 mgm. RaCl_2 , was crystallised from an acid solution, dried, and introduced into the calorimeter, and the rise of the heating effect observed over a period of several days. The observations were found to agree well with the theoretical formula $Q_t = Q_{\text{Ra}} + Q_{\text{E}}(1 - e^{-\lambda t})$, where Q_t , Q_{Ra} , and Q_{E} are the heat evolution of the whole, the radium itself and the emanation respectively and λ is the transformation constant of RaEm. The values deduced for Q_{Ra} and Q_{E} are 25.2 and 107.1 gm. cal. per hour respectively, giving a total of 132.3. Q_{E} includes the products as far as RaC in their equilibrium amounts. In the experiments all the α - and β -rays were absorbed and 18 % of the γ -rays. Assuming that all the heating effect of the radium without its products, is due to the kinetic energies of the α -particles and the recoil atoms the velocity of the former is deduced to be 1.595×10^9 cm./sec.

E. M.

712. *Laws of Surface Adsorption and the Potential of Molecular Attraction.* J. R. Katz. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 445-454, Nov. 28, 1912.)—Experiments are described on the adsorption of water by finely-divided synthetic quartz and synthetic anorthite. The substance was

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first left for some days in air which was in contact with 1 per cent. sulphuric acid solution, and was then allowed to reach a constant weight over aqueous sulphuric acid solutions of known vapour pressures; the adsorbed water was determined by igniting the substance. Curves connecting the adsorbed water as abscissæ with the relative vapour pressure, p/p_0 (where p_0 refers to pure water), are at first nearly horizontal, then nearly vertical, and finally nearly horizontal again. This characteristic form is regarded as related to the variation of the vapour pressure with the thickness of the film of water on the surface of the substance. The vapour pressure p and the potential of the molecular forces k are related according to the expression, $k = RT \ln p/p_0$, and application of this to the data obtained shows that the potential of molecular attraction diminishes rapidly as the thickness of the water-film increases, and that there exists a sphere of attraction which is moderately well defined, and which has the radius 1.3×10^{-6} cm. and 6.2×10^{-6} cm. for water on the surface of quartz and anorthite respectively. There is here no apparent relation to the density of the solid, but it seems that substances with many atoms in the molecule have a larger radius.

T. H. P.

713. Action of Ultra-violet Light on Water. W. Obolensky. (Ann. d. Physik, 89. 5. pp. 961-975, Dec. 5, 1912.)—Extreme ultra-violet rays act upon pure water so as to produce a photoelectric effect comparable with the effect upon copper oxide and other materials. The source of light used was the spark between Al electrodes, which emits effective rays of wave-lengths of approximately 185 and 180 $\mu\mu$. The latter group is cut off by a quartz plate 25 $\mu\mu$ thick. The 185 group was then weakened by extending the gap between the spark and the water surface from 8 mm. to 10 mm. All light below 204 $\mu\mu$ was cut off by a calcspars plate 3 mm. thick, and finally glass was interposed, which transmits only a small fraction of ultra-violet light. The shortest wave-length was found to be the most effective, the effect observed being $\frac{1}{1000}$ th of that in cupric oxide. The effect in water disappears at 202 $\mu\mu$. Slight impurities make no difference, but the addition of considerable quantities of chlorides reduces the photoelectric discharge, whereas sulphates, carbonates, and nitrates increase it. Ice shows an effect of the same order as cupric oxide, and so does hoarfrost. No effect of meteorological importance can be attributed to the action on water. But cirrus clouds, if composed of ice crystals, may well be electrically charged, as was assumed by Brillouin.

E. E. F.

714. Action of Ultra-violet Light on o-, m-, and p-Nitrobenzaldehyde and on Benzaldehyde. A. Kailan. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1829-1851, July, 1912.)—The bodies are dissolved in benzene or in alcohol, and radiated upon by a quartz mercury lamp for 10 or 15 mins. in vessels of quartz or of glass; the effects are stronger in the quartz vessels, and the glass turns brown. The aldehydes are oxidised to benzoic acid, similarly as by penetrating radium rays [see Abstract No. 598 (1912)] but much more rapidly, especially in benzene solutions. The velocity of the reaction increases with the concentration, but at a smaller than the proportionate rate; when the distance between lamp and solution is increased, the rate decreases less rapidly than it should according to the law of inverse squares. There is a considerable absorption of the rays by the solutions. The temperature coefficients are very small, as with all photochemical reactions. The oxidation seems to be due to the oxygen of the air or the ozone formed. Some of the solid substances are hardly affected.

H. B.

715. Action of the Penetrating (β and γ) Radium Rays. III. Action on Inorganic Compounds. A. Kailan. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1858-1884, July, 1912.)—The arrangements were as in previous experiments, the radium-barium chloride used containing in different tests up to 80.5 mgm. of metallic Ra. Ferric sulphate is reduced, especially in the presence of sucrose, the rate being more than twice as rapid as the formation of H_2O_2 (during the same period) from neutral water. This hydrogen peroxide is formed by the radiation from acid, neutral and alkaline water, the velocity of the reaction decreasing in the order stated. Potassium bromide is decomposed under liberation of bromine when dissolved in sulphuric acid; the rate hardly increases when the concentration of the salt or acid is increased, but is only a fraction ($\frac{1}{10}$ to $\frac{1}{100}$) of the rate of decomposition of potassium iodide, if the action of any H_2O_2 , possibly formed be neglected; potassium chloride is not decomposed. H. B.

716. Action of the Penetrating (β and γ) Radium Rays. IV. Action on Organic Compounds and Reactions. A. Kailan. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1885-1401, July, 1912.)—The velocity of the esterification of benzoic acid (if dissolved in absolute or aqueous alcohol) is catalytically accelerated by the presence of hydrochloric acid, but not affected by the radiation, from which it would follow that the radiation does not influence the dissociation of alcoholic hydrochloric acid either. The formation of a benzoic acid derivative from orthonitrobenzaldehyde is accelerated by the radiation (in alcoholic and in benzene solutions), but 90 mgm. of radium chloride have only $\frac{1}{10000}$ or $\frac{1}{100000}$ the effect of a quartz mercury lamp at 8 cm. distance, and the velocity of the reaction hardly increases with increasing concentration of the aldehyde. Quinone, which is easily decomposed by blue and violet rays, is not affected by the rays in ethereal or in alcoholic solution, nor did the rays accelerate the light effect. Oxalic acid is not changed at 25° by the rays after 1000 hours by 200 mgm. of salt. The rate of the inversion of unsterilised solutions of sucrose is accelerated by the rays, but strangely enough the growth of mould seems to be favoured by the rays. H. B.

717. Sunlight. P. C. Freer and H. D. Gibbs. (Journ. Phys. Chem. 16. pp. 709-788, Dec., 1912. Paper read before the 8th Internat. Congress of Applied Chemistry, N.Y., Sept., 1912.)—The supposed superiority in the influence of sunlight on chemical and physiological processes in the tropics over that shown in the temperate zone has been investigated by studying the photochemical action of tropical sunlight. No definite conclusion is possible from the examination of the effect of sunlight on the colouration of various benzene derivatives. The decomposition of oxalic acid in presence of uranyl acetate, which has a very low temperature-coefficient, was taken as a measure of the intensity of violet and ultra-violet radiation. Comparison of the average amounts of oxalic acid decomposed per hour throughout the year at various places shows lower figures for the higher latitudes; this is attributed to the lower proportion of clear days in these latitudes, since with a clear sky the activity is almost the same everywhere. The influence of tropical sunlight on animals and human beings was also investigated. T. H. P.

718. Diffusion of Uranium. G. v. Hevesy and L. v. Putnoký. (Phys. Zeitschr. 14. pp. 68-65, Jan. 15, 1918.)—An attempt was made to separate VOL. XVI.—A.—1918.

Ur I. from Ur II. by diffusion, but without success. If there are two such substances, as is made probable by the work of Boltwood [Abstract No. 1100 (1906)], Marsden and Barratt [Abstract No. 1848 (1911)], and Geiger and Nuttall, they must be chemically very similar. The most probable disintegration scheme is $\text{Ur I.} \rightarrow \text{UrX} \rightarrow \text{Ur II.} \rightarrow \text{Io} \rightarrow \text{Ra.}$

E. E. F.

719. Volume-changes of Amalgams. J. Würschmidt. I. (Deutsch. Phys. Gesell., Verh. 14. 28. pp. 1065-1087, Dec. 15, 1912.)—The author has investigated the change of volume with temperature of a series of amalgams, by a dilatometric method, a special dilatometer, suitable for the purpose being described. He finds that the amalgams of tin, lead, and cadmium, which according to Puschin are to be regarded as solid solutions, exhibit at the melting-point a very clearly marked maximum of the expansion coefficient, whereas the zinc amalgams, which are to be regarded as "mechanical mixtures," exhibit this maximum at a temperature considerably below the melting-point. In the case of sodium amalgams, a peculiar behaviour is found, namely, changes of volume occur with time, even at constant temperature, and moreover, the melting-point and freezing-point do not coincide.

A. F.

720. Alloys of Cobalt with Chromium, etc. E. Haynes. (Amer. Inst. of Mining Engin., Bull. No. 74. pp. 249-258; Discussion, pp. 258-255, Feb., 1918. Metallurgical and Chem. Engin. 10. pp. 804-806, Dec., 1912. Abstract. Mech. Eng. 80. pp. 819-820, Dec. 27, 1912.)—Using an alloy of cobalt with 15 % chromium as basis it has been found that tungsten increases the hardness until at 10-25 % the ternary alloy can be used for cutting tools. At 40 % tungsten the alloy will cut glass and scratch quartz. Molybdenum acts in the same way. The presence of carbon, silicon, and boron still further hardens the alloys, but also renders them brittle. All the alloys resist atmospheric influences remarkably well.

F. C. A. H. L.

721. The System Tin. A. Smits and H. L. de Leeuw. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 676-681, Dec. 30, 1912.)—The fact that tin exists in two crystalline forms, viz. the tetragonal having a sp. gr. of 7.25 and the rhombic with a sp. gr. of 6.55, in conjunction with the appearance of brittleness at 200° C. indicates the existence of a transition-point at about this temperatures. Dilatometric experiments using a non-volatile oil as liquid show that a slow transformation takes place at 200.8° C. Above this temperature expansion occurs, and below it contraction, while at 200.8° C. no change in volume takes place even after 4 days. The presence of mercury rapidly lowers the temperature of transition which accounts for Degens' low value for this point. Using mercury as the liquid in a dilatometer he observed the transition at 161° C. [See Abstract No. 1782 (1906).]

F. C. A. H. L.

722. Correspondence on Exothermic Steel. (Metallurgical and Chem. Engin. 10. pp. 712-718, Nov., and pp. 775-776, Dec., 1912.)—J. W. Richards casts considerable doubt on the process for making exothermic steel described in Abstract No. 186 (1918) and points out that the true formula for feldspar is KAlSi_3O_8 and not $\text{KAl}_2\text{Si}_2\text{O}_8$ as stated by Amsler. F. Gelsthorp takes exception to the introduction of hydroxide into an equation representing a reaction taking place at a temperature above that at which all hydroxides are decomposed. J. Hårdén describes an experiment in which 100 lbs.

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tungsten ore, 182 lbs. felspar, 60 lbs. bauxite, 10 lbs. lime, 4 lbs. carbon, and 6 lbs. iron were melted down in an electric furnace. A cake of fused semi-metallic material weighing 59 lbs. and containing 29.5 lbs. tungsten resulted. Thus 48.2 per cent. of tungsten was lost in the slag. **W. O. Amsler** defends the process and says it is in commercial operation, steel made by it being supplied to the U.S. Government. The reaction is not so vigorous as the thermit reaction and must be supported by external heat. **Härdén** used far too much bauxite and felspar.

F. C. A. H. L.

723. Structure of Cast Iron and Effects of Superheated Steam. **W. Campbell** and **J. Glassford**. (Rev. de Métallurgie, 9. pp. 1146-1153, Dec., 1912.)—It has been observed repeatedly that some cast irons, when subjected to the action of superheated steam, undergo a sort of corrosion which causes them to grow and become fragile, while others can be used for many years without showing any signs of corrosion. The authors have attempted to determine the nature of this corrosion, why it affects certain irons and not others, and how it can be reduced to a minimum. Microscopic examination of cast iron which had failed under the action of steam at 427° to 482° C. after about 2 years indicated that silico-ferrite is the most rapidly attacked constituent while cementite is the most stable. The mechanism of the action appears to be that the graphite plates first become surrounded by a thin film of oxide which is gradually added to until a complete network of oxide+graphite is formed, when the material becomes extremely fragile. Numerous varieties of steel, also grey, white, and malleable cast-iron have been subjected to the action of superheated steam at 425° C. for periods of 30 and 90 days. The results of subsequent determinations of changes in size and weight, and microscopic observations show that white cast-iron, steel, and malleable cast-iron become covered with a skin of oxide which fills all the cracks, etc. Grey cast-iron containing about 0.95 % Si shows a similar superficial oxidation, but in addition there is a slow penetration of oxide following the larger plates of graphite. This penetration increases with the content of Si and a new white constituent is precipitated round the oxidised areas. At 5.5 % Si the structure is completely altered. The corrosion appears to diminish with the fineness of the graphite plates. Repeated heatings and coolings (72) to and from 425° C. in the air only resulted in superficial oxidation.

F. C. A. H. L.

724. Modifications of Iron below 700° C. **F. Robin**. (Rev. de Métallurgie, 9. pp. 1088-1085, Dec., 1912.)—The author gives a list of the points of singularity revealed in iron up to 700° C. A review of the evidence based on mechanical, magnetic, thermoelectric, and sonority tests made by numerous workers, points to the existence of two allotropic changes in iron, one between 100 and 250° C., and the other between 400 and 500° C.

F. C. A. H. L.

725. Slag Enclosures. **W. Rosenhain**. (Rev. de Métallurgie, 9. pp. 998-1014, Dec., 1912.)—Under the term "slag enclosures" the author includes all fluid or semi-fluid substances which would be expelled from the steel during solidification and cooling under favourable conditions. Objection is taken to Hibbard's suggestion of "sonim" for the "solid non-metallic impurities in steel because of the introduction of a new term into the literature of a subject already overburdened with names, and because of the difficulty in deciding which are metallic and which non-metallic im-

purities. The researches of Matwieff and Levy are discussed, and it is suggested that the iron and manganese sulphides series and the iron and manganese silicates should be further studied, particularly as regards their solubility in iron. The mode of formation of the slag enclosures is not sufficiently well understood to permit of the formulation of definite rules for their elimination. They probably exist in minute globules in the molten steel, and steps should be taken to cause these globules to coalesce into larger ones which should then be given time to rise to the surface. With regard to the mechanical effect of the enclosures Ziegler has expressed the opinion that they form nuclei for the crystallisation of α -iron from austenite [see Abstract No. 766 (1912)], and while it is generally accepted that the presence of slag is a determining factor in the brittleness of steel, further research on this point is advisable.

F. C. A. H. L.

726. Biography of Pro-eutectoid Cementite. H. M. Howe and A. G. Levy. (Rev. de Métallurgie, 9. pp. 1075-1082, Dec., 1912.)—The zone between the austenite region and the Ar_1 line in the iron-carbon equilibrium diagram is called the "zone of transformation," and the cementite and ferrite generated in this zone are designated "pro-eutectoid" to distinguish them from pearlitic cementite and ferrite. A study of the pro-eutectoid cementite in hyper-eutectoid steel has been made by heating steels to temperatures between 1000° and 1800° C. and quenching after cooling to various temperatures between 700° and 960° C. and in other cases after maintaining at 800° C. for various periods of time. In every case the samples were subsequently tempered at 400° C. to facilitate cutting and to accentuate the contrast between the cementite and the ground-mass. In the zone of transformation the precipitation of cementite, like ferrite, appears to be rapid, but the rate of agglomeration is very slow. With decrease of temperature or increase of carbon-content the rate of agglomeration increases. Apparently the internal cementite is transferred to the network by a kind of dissolution of the fine needles and subsequent sublimation to the larger masses forming the borders of the original austenite grains. There appear to be two forces at work on the internal cementite: the network of cementite tries to force its orientation at the moment of formation or of reprecipitation, and the austenite tries to force the cementite into its cleavage planes at the moment of formation. Sometimes one action predominates, in other cases the other force prevails. The growth of grain-size is very much more rapid at 1200° or 1800° than at 1000° C. Increase of carbon also increases the rate of grain growth, although the presence of excess of internal cementite frequently masks this effect.

F. C. A. H. L.

727. Uniform Nomenclature for Iron and Steel. H. M. Howe and A. Sauveur. (Rev. de Métallurgie, 9. pp. 1048-1064, Dec., 1912.)—The report of the Commission appointed by the 5th International Congress for Testing Materials to solve the above problem was favourably received. Some of the definitions have been modified and additional ones added. In the opinion of the majority of the members there is room for radical alteration in the terms "blister steel" and "malleable cast iron." Unlike the other steels, blister steel has not been cast from the liquid state, but has been produced in a plastic condition, while the essential property of malleable cast iron, viz. malleability, is totally absent in all other varieties of cast iron. It is proposed therefore to remove blister, shear, and double-shear steels from the general class of steels and malleable cast iron from the class of cast iron, and to bestow upon these materials new and distinctive names.

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The English members of the Commission strongly oppose these proposals on the grounds that the Commission was not appointed to introduce new terms, but to define clearly the existing ones. Blister Steel and Malleable Cast Iron have been so well known for so long a period that any change in their description is bound to lead to confusion.

F. C. A. H. L.

728. Nomenclature of the Micro-constituents and the Micro-structures of Steel and Cast Iron. H. M. Howe and A. Sauveur. (Rev. de Métallurgie, 9, pp. 983-997, Dec., 1912. Report to the Internat. Assoc. for Testing Materials.)—This is the report of the Commission appointed by the above Association, and is a continuation of the work described in Abstract No. 1082 (1910). Division into metals and aggregates is adhered to, and the plan followed has been to consider only generally accepted principles and theories. First there is the liquid iron, which forms austenite, cementite, and graphite during solidification. During the transformation of austenite, martensite, troostite, and sorbite are formed as intermediate products; the final products being ferrite and pearlite. Other and rarer constituents are: ledeburite (Wüst)—the austenite-cementite eutectic, ferromanganese (Benedicks)—iron containing about 0.27 % of carbon, steadite (Sauveur)—the iron-iron phosphide eutectic, and the three transition products hardenite (Arnold), osmondite (Heyn), and troostite-sorbite (Kourbatoff). The latter is falling into disuse, while osmondite is described as the limiting phase between troostite and sorbite. Each of these constituents is fully described, its name being given in English, French, and German, and other titles are indicated if any such exist. Manganese sulphide is also included as a micro-constituent of steel. It is considered that the terms saturated, super-saturated, and non-saturated steels are liable to lead to errors, and should therefore be dropped in favour of the terms eutectoid, hyper-eutectoid, and hypo-eutectoid.

F. C. A. H. L.

729. Influence of Geometrical Shape on Chemical Action. G. Reboul. (Comptes Rendus, 155, pp. 1227-1229, Dec. 9, 1912.)—A small plate of copper was introduced into a very high vacuum by attaching it to an iron support floating on mercury, and raising the level of the mercury until the copper was inside the large vessel. The iron support also held a piece of vulcanised rubber, which slowly emits sulphur vapour. The vapour gradually blackened the copper, but the blackening commenced at the edges, and reached the centre of the surface last. The position of the plate was immaterial. The velocity of reaction increases with the curvature of the surface. An ellipsoid is first attacked at the two ends. When two copper spheres are placed close to each other, and exposed to sulphur vapour, the smaller sphere is blackened first. Care must be taken to avoid turbulence in the attacking gas, hence the precaution of using vulcanised rubber.

E. E. F.

730. Spontaneous Variations of Concentration. T. Svedberg. (Phys. Zeitschr. 14, pp. 22-26, Jan. 1, 1913.)—The relative mean deviation from the mean concentration of molecules in a given volume of liquid or gas is $\sqrt{1/\nu}$, where ν is the mean number of molecules in the volume. The author discusses the methods by which such variations of concentration might be discovered. Radio-active bodies, whose individual atoms can be observed at the moment of disintegration, appear to offer the best facilities. The probability of disintegration is the same as the probability of concentration, so that the total deviation from the mean should be $\sqrt{2/\nu}$. Some experiments made with Ra emanation and polonium solutions (to be fully described shortly)

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appear to confirm this. Since 1910 the author has made numerous attempts to observe similar deviations in other molecules, notably in fluorescent substances. Rhodamin can be perceived by dark-ground illumination when the concentration is as low as 10^{-7} normal. This gives 60 molecules per cubic micron, and a spontaneous variation of 13 per cent. should be observable. But nothing of the kind was seen. If the emission of light by the fluorescent molecules is by quanta, these flashes would be much more numerous than the molecules, and, emanating from molecules in rapid motion, might mask the effect sought.

E. E. F.

731. Dielectric Constants of Dissolved Salts. II. P. Walden. (Acad. Sci. St. Pétersbourg, Bull. 18. pp. 1055-1086, Dec. 15, 1912.)—Investigations similar to those previously made with chloroform solutions [Abstract No. 924 (1912)] have been carried out with solutions in dichloromethane (dielectric constant, 8.8) and in ethyl formate (8.2), which differ from chloroform in giving measurable ionic dissociation of the salts employed (*loc. cit.*); further, ethyl formate being a solvent of an entirely different type, its use opens up the possibility of studying the chemical rôle of the atoms constituting the solvent. As with chloroform, so also with dichloromethane, the dissolution of the salts is accompanied by considerable increase in the dielectric constant of the solvent. Further, these constants for the salts, calculated by Philip's, Bouty's, and Silberstein's formulæ, are mostly very high, the greatest values being obtained with the first of these formulæ. In dichloromethane, the value of the constant for any salt is much higher than in chloroform. This constant also increases with the complexity of the salt and, according to Philip's formulæ, has the values; $\text{NH}(\text{C}_2\text{H}_5)_2, \text{HCl}$, 88; $\text{N}(\text{C}_2\text{H}_5)_3, \text{HCl}$, 890 and $\text{N}(\text{C}_2\text{H}_5)_4, \text{Cl}$, 1980. For any one salt at equal dilutions, the molecular conductivity is from 10 to 80 times as great in dichloromethane as in chloroform and, whilst in the latter solvent it diminishes rapidly and continuously as dilution increases, in the former a minimum is observed at a certain dilution. It is concluded that the ions formed from the salt are able to raise the dielectric constant of the solution and also the dissociating power of the solvent. Ebullioscopic measurements show that the salts have different molecular magnitudes in the two solvents, these being, for $\text{N}(\text{C}_2\text{H}_5)_4, \text{Cl}$, M_2 in chloroform and M_1 in dichloromethane and for $\text{N}(\text{C}_2\text{H}_5)_3, \text{HCl}$, M_2 and M_1-M_2 respectively. The chemical process of salt formation by the conjunction of the two neutral constituents [$\text{N}(\text{C}_2\text{H}_5)_3 + \text{C}_2\text{H}_5\text{Br}$, &c.] is expressed physically in a reconstruction of the dielectric properties of these constituents in such a way that the new product shows a dielectric constant about 6, 13, or 18 times that calculated additively for secondary amine, tertiary amine, and tetralkylammonium salts respectively. Calculation by means of the Clausius-Mosotti equation, $x = (K - 1)/(K + 2)$, where x represents the fraction of the total volume actually occupied by the molecules, shows that those salts are the best electrolytes for which x approaches the value 1. Not only is the general behaviour of ethyl formate as regards the alteration of the dielectric constants of dissolved alkylamino-salts similar to that of dichloromethane, but the actual values of these constants are very nearly equal with the two solvents. Sodium iodide and lithium bromide are characterised by extremely high dielectric constants in ethyl formate—5595-6820 and 4760-5800 respectively, according to Philip's formula; calcium iodide shows a much smaller value (1540) and mercuric chloride one still smaller (490). Thus, the dielectric constant of these salts diminishes with their capacity to dissociate. Results obtained with solutions of salts in the strongly-ionising solvents, acetone,

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acetylacetone, acetonitrile, and propionitrile, confirm the conclusion that, if the dielectric constant of the medium remains constant, the formation of ions increases the ionising tendency and the degree of electrolytic dissociation of the salt. Certain anomalies exhibited by solutions are discussed in connection with the increases produced in the dielectric constants and hence in the ionising power of solvents by the dissolution of electrolytes. It is pointed out that this phenomenon must be taken into account in considering deviations from the law of mass action (Ostwald's dilution law), the rôle of neutral salts, the disagreement of salts dissolved in media having feeble ionising actions with the requirements of the theory of Arrhenius, etc., since by it, as well as by the other well-known factors, the degree of electrolytic dissociation is appreciably altered.

T. H. P.

732. *The Wet Oxidation of Metals. II. The Rusting of Iron (continued).* B. Lambert. (Chem. Soc., Journ. 101. pp. 2056-2075, Oct., 1912.)—The experiments of Moody and Friend prove only that passive iron may be kept from corrosion in contact with water and air in the absence of acid constituents, their samples having been previously rendered passive by treatment with chromic acid and caustic soda respectively. Extraordinary precautions have been taken to prepare pure oxygen and pure water by electrolysis and distillation of solutions of chemically pure barium hydroxide in conductivity water. The water was distilled on to the iron contained in a quartz tube and the presence of CO₂ was tested for repeatedly by means of a Plücker tube. In spite of all these precautions, rusting took place in three commercial forms of iron, apparently as quickly as in ordinary water and air or oxygen. A pure metal is scarcely affected by electrolytes, but in contact with a more electro-negative metal it dissolves and generates a current flowing through the electrolyte from the electro-positive to the electro-negative pole. The rate of reaction, or the amount of current flowing, depends upon the difference of solution pressure between the two metals or modifications of the same metal and upon the resistance of the electrolyte. Commercial iron is non-homogeneous, so that all the conditions for the production of an electric current exist when the metal is immersed in electrolyte water. In the absence of oxygen, solution is infinitely slow owing to the small differences of potential between the different parts of the metal and the great resistance of the pure water. Rusting takes place, however, in the presence of oxygen, and since solution must necessarily precede rusting, it follows that oxygen must either reduce the resistance of the water or increase the differences of solution pressure between the various parts of the metal. Pure iron prepared by the author has been kept in contact with pure water and pure oxygen for over two years without showing any visible signs of rusting. If a piece be removed and locally deformed, signs of corrosion appear after 1 hour's immersion. Immersion of other samples of the pure iron in a normal solution of salt resulted in rusting even after a few hours. That constituents of the air other than oxygen, play little or no part in the process is shown by the fact that rusting is just as rapid in pure oxygen. Sulphuric acid, nitric acid, sulphates, and nitrates have much less action on pure iron than hydrochloric acid and chlorides. Pure iron will withstand the action of saturated copper sulphate and nitrate solutions for an indefinite period, but local deformation results in the immediate deposition of copper. In copper chloride solution copper is immediately deposited. The protective action is not due to the formation of oxides, but to the fact that certain materials reduce the differences of potential existing in all commercial irons. Passive irons therefore possess

an "electrically equable surface." The author's pure iron does not give rise to positive and negative nodes in the ferroxyl reagent, except after local deformation, when the part deformed goes into solution and generates the blue zone. It seems probable, therefore, that the fundamental cause of the rusting of iron is not carbonic acid, but is to be sought in differences of solution pressure between different parts of the metal.

F. C. A. H. L.

733. Action of Electrolytes on Metals subjected to Stresses. H. Baucke. (Rev. de Métallurgie, 9. pp. 1154-1159, Dec., 1912.)—Recent electrochemical researches on corrosion have revealed differences of potential between electrodes of the same metal subjected to different thermal or mechanical treatments. The metastable metal always becomes the anode, and it would appear that contact with an electrolyte should accelerate the reversion of the metastable to the stable form. It has been observed by the author that steel balls (used for bearings) which frequently break in service, reveal the existence of crevices after etching with alcoholic hydrochloric acid. These fissures exist internally as well as externally, and under high magnifications show an undulating appearance at the edges. They are not directly produced by the etching, but during hardening local contractions are set up, and these give rise to superficial folding followed by the development of fissures. The system of heating boiler-plates frequently results in the development of cracks even in very pure materials. Wrought iron shows less tendency to crack so that the fault cannot be attributed to slag. The fissures are the outcome of deformation and the subsequent tendency of the material to revert to its stable state. In both cases the fissures are revealed by contact with an electrolyte which apparently accelerates the conversion of the amorphous material produced by hardening contractions in the case of the balls, and by deformation in the case of the plates into the stable form.

F. C. A. H. L.

734. Properties of Fused Carnallite. K. Arndt and H. H. Kunze. (Zeitschr. Elektrochem. 18. pp. 994-998, Nov. 15, 1912. H. H. Kunze's Dissertation, Berlin, 1912.)—An artificial carnallite (raw material for the magnesium electrolysis) was prepared by mixing KCl and MgCl₂, adding some NH₄Cl to prevent the decomposition of the fused MgCl₂. The freezing-point of theoretical carnallite is 496°; by further adding from 86 to 80 per cent. of KCl the freezing-point was lowered to 498° and finally to 486°, but the curves were not regular. Density and conductivity (electric) measurements are also made between 550° and 780°; comparative data for pure MgCl₂ could not be obtained, as it decomposed. The statement of A. Oettel (Dissertation, Dresden, 1908) that magnesium can, like calcium, be gained in stick-form when the kathode is slowly being lifted during the electrolysis is confirmed; great care is needed, however.

H. B.

735. The Equation of State for Solids, and the Theory of Specific Heats. E. Rasch. (Königl. Materialprüfungsamt, Mitt. 80. 5. and 6. pp. 820-848, 1912.)—In the present communication, which is stated to be of a preliminary character, the author criticises the equations of Einstein, Nernst, and Lindemann for the specific heats of solid substances. He points out that these equations, which are of a rather complex character, fail to express the experimental results because the assumption is falsely made that the upper value of the molecular heat (b_{∞}) is a universal constant, whereas, according to the author, it is a characteristic material constant, and has, in general, a greater

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value than that assigned to it by the Einstein-Nernst theory. In place of these equations the author deduces a set of much simpler equations which he expresses in the differential and integrated forms as follows:—

$$dQ = b_{\infty} e^{-\theta/T} dT ; c = c_{\infty} e^{-\theta/T} ; b = b_{\infty} e^{-\theta/T} ;$$

in which c and b are the specific and atomic (or molecular) heats respectively, e is the base of the natural logarithms, T is the absolute temperature, and θ is a characteristic constant for the material, and represents a definite temperature. By means of a number of experimental results the author shows how his equations are in accordance with the results of experiment. A. F.

736. Heats of Dilution. W. F. Magie. (Phys. Rev. 85. pp. 265–271, Oct., 1912.)—A study of the constants of the formula which represents the heat capacity of a solution shows that the number of degrees of freedom of the undissociated molecules of the solute and of the water affected by them is increased by solution, and that the number of degrees of freedom of the ions and of the water affected by them is always decreased. As dilution proceeds and the molecules break up into ions, the number of degrees of freedom of the solution diminishes both by the removal of molecules from the solution and by the introduction of new ions, the change in the number of degrees of freedom being proportional to the change in the amount of dissociation. At the temperatures now under consideration the energy associated with a degree of freedom is proportional to the absolute temperature. An evolution of heat proportional to the change in dissociation and to the absolute temperature is thus accounted for. T. M. L.

737. Critical Coefficient and Molecular Weight of Substances at the Critical Point. A. Boutaric. (Comptes Rendus, 155. pp. 1080–1082, Nov. 25, 1912.)—Guldberg showed that the absolute boiling-points of very varied liquids were in all cases about two-thirds of the absolute critical temperatures. Since the boiling-points are corresponding temperatures for all liquids, the volumes at the boiling-points should also correspond, *i.e.* v/ϕ should be constant, where v is the specific volume of a liquid at its boiling-point, and ϕ is the critical volume. Further, as van der Waals' theory shows that $\phi = 3b$, it follows that v should be proportional to b . The mean value of v/b for thirty liquids is 1.20, the deviations not exceeding 10 per cent. Since $v = M/d$, where M is the molecular weight and d the specific gravity of the liquid at the boiling-point, and since also, according to van der Waals' theory, the critical temperature, θ , is given by $8/27 \cdot a/bR$ and the critical pressure, π , by $a/27b^2$, it follows that $\theta/\pi = 0.1176 \cdot M/d$, so that the critical coefficient, θ/π , can be calculated from the molecular volume of the liquid at the boiling-point. With many organic liquids the molecular volumes can be calculated additively from the volumes of the constituent atoms, and the critical coefficient of a substance can hence be calculated from its molecular formula. If a substance at the critical point has the molecular weight, not M , but $a \cdot M$ owing to polymerisation, and if this degree of polymerisation is invariable, the specific volume at the boiling-point is aM/d , and therefore $b : aM/d = 1.2$ or $b : \mu/d = 1.2a$. If the quotient $b : M/d$ is greater than 1.2, a is greater than 1 and the liquid is polymerised, as is the case with water, alcohols, thiophene, etc. But for most substances the quotient $b : M/d$ is equal to 1.2, which is in agreement with Guye's result that, at the critical point, the molecular weight is the same as in the gaseous state. T. H. P.

738. Equivalent Conductivity and Ionisation of Nitrites. P. C. Rây and N. Dhar. (Chem. Soc., Journ. 108. pp. 10-18, Jan., 1918.)—The authors have determined the equivalent conductivities at 20° for varying dilutions of the following nitrites. The equivalent conductivities at infinite dilution are given in brackets. The nitrites of ammonium (128·8), lithium (98·7), sodium (104·8), calcium (112·9), strontium (118), barium (116·75), magnesium (106·9), zinc (108·1), silver (115·2), tetramethylammonium (99·2), phenyldimethylethylammonium (85·4), isobutylammonium (91·8), butylammonium (91·8), allylammonium (94), dipropylammonium (82·9), propylammonium (95·4), tripropylammonium (78·2), diethylammonium (88·7), triethylammonium (105·2), nickel (94·0), and copper (106·8); also of sodium mercurinitrite, tetramethylammonium mercurinitrite and mercurosomercuric nitrite. In no case was the max. value of the equivalent conductivity observed directly, owing to hydrolysis. The results show that the amine nitrites behave like typical ionogens, and are similar to alkali and alkaline earth nitrites. [Compare Abstract No. 1596 (1912).] T. S. P.

739. Dissociation Pressures and Melting-points of the System Copper-Cuprous Oxide. R. E. Slade and F. D. Farrow. (Roy. Soc., Proc. Ser. A. 87. pp. 524-534, Dec. 13, 1912.)—Investigation of the melting-points of mixtures of copper and cuprous oxide shows that the system is similar to that of phenol and water. The melting-point of the pure oxide is about 1210°. At temperatures above 1195° mixtures having a composition between 20 and 95 per cent. of cuprous oxide separate into two layers. Up to 1400° there is only a slight narrowing of this range of concentration, so that rise of temperature causes only a small increase in the solubility of one liquid phase in the other. The dissociation pressures were determined with the aid of the electric furnace devised by Slade [see Abstract No. 687 (1913)], and the pressures of oxygen measured are given in the form of curves showing their dependence on the time. The dissociation pressure over the fused mixture of metal and oxide is 4 mm. at 1205°, 10 mm. at 1240°, 12 mm. at 1260°, and 25 mm. at 1324°. Calculation of the heat of dissociation by means of van't Hoff's formula gives the value -90,060 gm. cal. at 1205-1260° and -55,890 gm. cal. at 1260-1324°, the value for the dissociation of solid cuprous oxide at the ordinary temperature into oxygen and solid copper being -81,600 gm. cal. The value is hence not independent of the temperature, and this is what would be expected, if the composition of the two liquid phases changed with the temperature; that this actually occurs is indicated by the results obtained. T. H. P.

740. Mode of Ionisation of Sulphuric Acid in Dilute Aqueous Solution. J. A. Muller. (Comptes Rendus, 155. pp. 1499-1502, Dec. 23, 1912.)—Electrolytic dissociation of sulphuric acid may give either SO_4'' or HSO_4' . In the latter case, the law of mass action gives for very dilute solutions $\alpha^2/v(1-\alpha) = K_\infty$, where α is the degree of dissociation for the molecular solution volume v and K_∞ is the equilibrium constant at infinite dilution. The dissociation constant changes with the volume, so that $K_v = f(v)$. The author finds that—

$$(K_v - K_\infty)/(v + \mu) = \lambda,$$

where μ and λ are constants. The dependency of K_∞ on the temperature is expressed by $\ln K_\infty = 23.8722 - 0.189883T + 0.00026638T^2$, whence—

$$d \ln K_\infty / dT = 0.00058266T - 0.18988.$$

T. H. P.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1913.

GENERAL PHYSICS.

741. *Comparator for a Base Unit at Potsdam.* F. Kühnen. (Zeitschr. Instrumentenk. 88. pp. 1-9, Jan., 1918.)—An elaborate comparator of the usual type for comparison of 4-metre or 5-metre standard bars with 1-metre standards. Details are not given very fully, but there are good drawings and photographs. No results to indicate accuracy are given. P. E. S.

742. *The Reinecker Measuring Machine.* A. Leman. (Zeitschr. Instrumentenk., Beib. 4. pp. 88-89, Feb. 15, and pp. 45-48, March 1, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—The peculiarity of this machine as compared with the usual mechanical-touch machine, invented by Whitworth, is that indication of contact is shown by the rise of a dilute solution of alcohol in a capillary glass tube. Sectional drawings are given and some methods of adjustment are indicated. P. E. S.

743. *Test of Circle-dividing Machines.* G. Foerster. (Zeitschr. Instrumentenk. 88. pp. 10-19, Jan., and pp. 89-91, Feb., 1918.)—A considerable amount of theory is involved in comparing two machines (*a*) by Heyde, (*b*) by Hildebrand, the error of a single measurement and also the mean error for a number being worked out in each case. Calibration tables and curves are given, the greatest error found anywhere on either machine being 1.5 seconds of arc. P. E. S.

744. *Stereophotographic Surveying.* O. Lemberger. (Eng. News, 89. pp. 602-612, March 27, 1918.)—Gives a short history of the development of photographic surveying in Europe, with some examples of photographic location of certain railways, such as the Jungfrau Railway, and also examples of topographical surveys. The theory of photogrammetry is briefly explained, and also the theory and practice of stereophotogrammetry. The instruments used for the latter, the stereomicrometer and the stereocomparator, are dealt with, diagrams of their construction being given, with examples of their practical application. Finally, an instrument called the stereo-autograph is described, which automatically draws a map while an operator manipulates

the stereocomparator. Contour lines may be drawn automatically on a map or on a photographic print. Illustrations are given of the use of the instrument for a survey of the Ostler Mountains in Tyrol, and other possible uses are suggested.

A. W.

745. Relation between the Deflection of a Beam and the Internal Stresses. A. Rejto. (Rev. de Métallurgie, 10. pp. 262-277, Jan., 1918.)—The author has previously shown that the specific resistance of tenacious materials is a function of the actual tension, the uniform elongation per cent., and the angle of slip. The proof is now extended mathematically to the case of the deflection of beams, and is supported by actual tests. The conclusion is that the three functions mentioned are in reality the characteristic properties of the material.

E. J. S.

746. Resistance of Thick Cylinders to Rupture. Malaval. (Rev. de Métallurgie, 10. pp. 214-219, Jan., 1918.)—In a tube of the proportions of gun practice, thickness about equal to inside diam., there are two distinct periods besides the elastic range. The latter is followed by the range of semi-elasticity or partial failure which is of sensibly the same duration in stress. With increasing applied pressures the area of overstressed metal widens radially outwards. Thus if the pressure is released the outer elastic zone is prevented from returning completely to its original shape by the permanent deformation of the inner plastic zone. The mutual action causes the unloaded tube to be stressed in tension in the outer region and in compression in the inner, so that it is in the condition of an ideal shrunk composite tube, *i.e.* one with an infinite number of indefinitely thin components whose mutual pressures are such that under rising internal pressure all parts reach the elastic limit simultaneously and bear equal parts of the load. The semi-elastic period ceases when the outside layer reaches the limit of elastic deformation, and is followed by the period of general failure. During this period, covering an increase of resistance much greater than those of the first two periods, all parts show an increase of resistance, the inner region being in compression and the outer in tension. It follows that the metal, whose capacity for deformation is greater in compression than in tension, can withstand very considerable internal strains. It is concluded that the ordinary shrinking process might be replaced advantageously by one involving initial overstraining of a solid tube. A gun so constructed would withstand a pressure of over 15,000 kg. per sq. cm.

E. J. S.

747. Some Static and Dynamic Endurance Tests. J. O. Roos af Hjelmsäter. (Rev. de Métallurgie, 10. pp. 68-69, Jan., 1918.)—Experiments have been made to determine the endurance under static rotatory bending tests and to dynamic stresses produced by repeated shocks of definite energy, of various steels subjected to different thermal treatments. Rotatory bending tests were carried out on a machine of the Wöhler type rotating at 1800 revs. per min., the limit of endurance being taken as the stress in kg. per sq. mm. producing rupture after 1,000,000 revs. In the annealed state a steel of 0.4 % carbon gave a figure of 22, and a 0.65 % carbon steel showed 25, while after hardening at 850° C. and tempering at 550° C. the figures rose to 28 and 38 respectively. The test is not recommended for specification purposes, but should prove of great value in determining the material and thermal treatment suitable for a particular purpose. Dynamic tests were made in the Gustafsson machine, in which the specimen is clamped vertically at its lower end while

the upper end is subjected to alternate impacts at each end of a diam. from two pendulum spheres, each pendulum of 250 mm. length and 1 kg. effective weight making 50 impacts per min., the number of blows for fracture being determined. It is proposed to carry out further tests on highly phosphoric steels with the object of determining if fragility makes itself felt under the small fatigue shocks, but it seems probable that fragility is most obvious when the energy of the shock is considerably higher than the elastic limit of the metal so that rupture is effective in one or a few blows. F. C. A. H. L.

748. Theory of a Shock Tensile Testing Apparatus and the Error involved in its Use. N. Davidenkof. (Rev. de Métallurgie, 9. pp. 1184–1188, Dec., 1912.)—In the Amsler-Laffon type of tension shock-testing apparatus, the specimen is inserted between two shackles and the whole allowed to fall vertically. At a certain point the upper shackle is arrested; the lower one proceeds with a velocity sufficient to break the test-piece, and the kinetic energy of the lower shackle is measured immediately before and after fracture. This entirely neglects the work of deformation produced by the upper tup, which may under unfavourable conditions amount to 50 per cent. of that produced by the lower tup, and thus leads to results which are false. A large number of tests made by the author have shown that the upper shackle is not really arrested but rebounds, fracture actually taking place during the period of rebound. He has investigated mathematically the error introduced and the conditions under which it can be neglected. F. C. A. H. L.

749. Shock Tests with Notched Bars for High-tension Steels. A. Gessner. (Rev. de Métallurgie, 9. pp. 1171–1178, Dec., 1912.)—The author has been brought to the conclusion that the 75-kg. pendulum impact machine considered by Ehrensberger as generally suitable for test-bars 80 × 80 mm. in section with a round notch 4 mm. diam., is not suitable for all classes of steel. It has been found necessary to adopt a test-piece 10 × 80 mm. in section for high-tension steels, and a large number of tests have revealed interesting phenomena. Two types of fracture may occur and the resilience may vary by 50 per cent. according to the type of break produced. Further discrepancies are introduced by local deteriorations produced by the edge of the hammer, and by adopting a sharper-edged hammer the resilience may be diminished by 26 per cent. Similar phenomena occur, but are less frequent, in the larger bars, particularly in bronzes and forged steels, and the author considers that extreme fragility is best indicated by a more simple test, such as Heyn's bending test. F. C. A. H. L.

750. Notes on the Brittleness Test. M. Derihon. (Mech. Eng. 81. pp. 64–65, Jan. 17, 1918. Paper read before the Internat. Assoc. for Testing Materials.)—Long experience has shown that the brittleness test (Frémont drop weight) is not so stringent as is generally believed. By efficient heat treatment it is possible to reduce the rejections to 0·8 per cent. The small Frémont type of test-piece is to be preferred to the Copenhagen type, since it more readily reveals local defects. No trouble has been experienced owing to the sharp 1-mm. nick, which is simple and inexpensive to produce. Great importance is attached to a high velocity of impact and to arranging the anvil so as to take up the whole of the impact elastically. At the Derihon works the brittleness test has been generally adopted for determining the suitability of material. F. C. A. H. L.

751. Tensile Yield-point and Collapsing Load of Struts. O. Greger. (Rev. de Métallurgie, 10, pp. 298-302, Jan., 1918.)—Tests made on rolled mild steel plate and angle showed that the modulus of elasticity, calculated from collapsing tests on struts by Euler's formula, increased rapidly with increase of yield-point in tensile tests. When the yield is about 19 kg. per mm.², E is about 15×10^5 kg. per cm.². The value rises to E about 20×10^5 kg. per cm.² when the yield-point is about 24 kg. per mm.². The shape of the curve suggests that E becomes nearly constant at the low values of yield-point, viz. 19 kg. per mm.². F. R.

752. Influence of Temperature on Gaseous Turbulence. C. Schaefer and G. Frankenberg. (Phys. Zeitschr. 14, pp. 89-98, Feb. 1, 1918.)—A criticism of Sorkau's work [Abstract No. 28 (1918)] on turbulence in gas currents through tubes. The authors confirm Sorkau's observation of three degrees of turbulence into which the steady Poiseuille current breaks up on successively increasing the speed beyond certain limits. But they controvert Sorkau's conclusion that the constant of turbulence I. has a simple relation to the absolute temperature, and that turbulences II. and III. are practically independent of the temperature. They show this by a simple application of Reynolds' dimensional method. They deduce a constant which fits the facts better than Sorkau's. This shows incidentally that the hydrodynamical equations also apply to turbulent streaming, which has sometimes been doubted. There is a complete analogy between the motion of solids in liquids and the turbulent motion of gases in capillaries. G. Mie. (Ibid. pp. 98-96, Feb. 1, 1918.) E. E. F.

753. Measurement of Gas Velocities. W. Altberg. (Akad. Wiss. Wien, Ber. 121. 2a, pp. 1589-1594, Oct., 1912. Communication from the Inst. für Radiumforschung.)—The method depends on the resistance of a small sphere placed in the region of flow of a gas. The sphere is suspended by a thin wire (length L), and the resistance W measured by the displacement l ; W being equal to $mg\ l/L$. W is also equal to $k\eta v + b\delta v^2$, where r is the radius of the sphere, v the velocity of flow, η the viscosity of the gas, and δ its density. k and b are constants equal to 100 and 1 respectively. Thus v can be calculated. The method is shown to be applicable to all ranges of velocity. E. M.

754. Studies of Dendritic Structures in their Application to Metallography and to Electric Discharges. R. Arpi. (Ark. för Mat., Astron. och Fysik, Stockholm, 8. 14, pp. 1-11, 1912.)—When a layer of liquid is arranged between two glass plates and the latter then separated, the liquid assumes a dendritic form. The author's experiments, made with machine oil, water, alcohol, and turpentine, show that these forms are of two kinds: positive, in which the structure (here formed by the air) grows inwards from the edge, and negative, or those which are formed by the partially displaced liquid. The configuration of the structure depends on the mass, viscosity, and adhesion of the liquid and on the capillary tension of the surface layer. The greater the speed at which the structure is formed the greater will be its surface, that is, the finer its branchings. Similar relations hold in the formation of metallographic structures on solidification, although in this case the action of crystallographic vectorial forces comes into play. Comparison of the two forms of dendritic structure shows, however, that such action is extremely small in many cases. Similar limiting surfaces must, in general, be expected when, VOL. XVI.—A.—1918.

for instance, the explosion of a gas or liquid causes the latter to strive to distribute itself rapidly in a surrounding medium. The marked similarity between the structures formed by electric discharges and those obtained by the author is hence readily understood; especially close is the likeness in the case of Lichtenberg's figures. T. H. P.

755. *Relativity, Mass, Force, and Energy.* R. D. Carmichael. (Phys. Rev. 1. Ser. 2. pp. 161-178, Feb., 1918.)—In a previous paper the theory of relativity was treated in a new way [see Abstract No. 19 (1918)]. The same method is now applied to the treatment of mass, force, and energy, and their fundamental properties. In the derivation of these results the theory of electricity is not employed, but the ordinary relativity relations are obtained. E. H. B.

756. *Gravitation and Electricity.* G. Borelius. (Phys. Zeitschr. 18. pp. 972-978, Oct. 15, 1912.)—Shows, on certain assumptions regarding the potential due to several different positive and negative kinds of electricity, that the gravitational mass of an uncharged body is not necessarily proportional to the number of electrons it contains. E. E. F.

757. *Perrot's Experiment to Establish the Earth's Rotation.* O. Tumlirz. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1481-1490, Oct., 1912.)—A discussion of Perrot's experiment proposed in 1859. [See Abstract No. 378 (1909).] E. H. B.

758. *The "Kilogramme" as a Unit of Force.* E. Budde, K. Strecker. (Zeitschr. Vereines Deutsch. Ing. 57. pp. 808-805, Feb. 22, 1918.)—Discusses the use of the word "kilogramme" in the sense of m and of mg ; points out that the latter is good for engineers' statical calculations, but is becoming increasingly inconvenient in dynamical calculations. Suggests that the kilogramme-unit of mg be called a "kilobar"; so that 1 kilowatt = 102 kilobar-metres. A. D.

759. *The Errors in a Repetition-theodolite.* O. Israel. (Zeitschr. Instrumentenk. 88. pp. 61-68, Feb., 1918. Dissertation, Dresden, 1912.)—After treating the general theory of errors as applied to this kind of instrument, the author considers the special case of an instrument due to Heyde, the dimensions and component details of which are given. P. E. S.

760. *Deformation and Interference of Waves in Gases.* L. Crussard. (Comptes Rendus, 156. pp. 447-450, Feb. 10, 1918.)—The author first investigates the deformation of a plane wave traversing a perfect gas, and then considers the interference produced by certain disturbances. H. H. Ho.

761. *Automatic Registration of the Relation between Stresses and Deformation of Materials under Shock.* A. Gagarine. (Rev. de Métallurgie, 9. pp. 1189-1207, Dec., 1912.)—The author describes the construction and use of an apparatus for recording the behaviour of materials during shock tests. F. C. A. H. L.

762. *The Structure of the Atom.* J. J. Thomson. (Engineering, 95. pp. 282-288, Feb. 14; 268-268, Feb. 21; 800-802, Feb. 28; 848-847, VOL. XVI.—A.—1918.

March 14, and pp. 897-898, March 21, 1918. Electrician, 70. pp. 1096-1097, March 21, and pp. 1188-1185, March 28, 1918. Abstract of lectures delivered before the Royal Inst.)

763. *Minkowski's Mechanics.* F. J. de Wisniewski. (Ann. d. Physik, 40. 2. pp. 887-890, Feb. 4, 1918.)—Mathematical. E. H. B.

764. *Relativity Equations.* C. Cailler. (Archives des Sciences, 85. pp. 109-189, Feb., 1918.)—An analytical treatment of the principle of relativity and its geometry. [See Abstract No. 2277 (1905).] E. H. B.

765. *Space-time Lines in Minkowski's "World."* F. Kottler. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1659-1759, Oct., 1912.)—A mathematical treatise on this four-dimensional geometry. E. H. B.

766. *Molecular Theory.* H. A. Lorentz. (Archives Musée Teyler, 1. Ser. 8. pp. 48-74, 1912.)—A lecture on various modern aspects of molecular theory, including radio-active transformations, Brownian movements, and the laws of radiation. E. E. F.

767. *Relativity and Kinematics.* E. Borel. (Comptes Rendus, 156. pp. 215-218, Jan. 20, 1918.)—By consideration of three systems with velocities differing in magnitudes and directions, the author reaches the following conclusion :—A system which to observers on it increases uniformly in its translational velocity ought to appear in rotation to observers not on the system. [See Abstract No. 828 (1918).] E. H. B.

768. *Rainfall over the Balkan Peninsula.* F. Trzebitzky. [Review by M. Maraković.] (Meteorolog. Zeitschr. 29. pp. 517-522, Nov., 1912.)—Rainfall records are lacking in many parts of the Balkan peninsula, especially in Servia and Turkey, while in other parts they refer to different epochs or form incomplete series. The author gives tables for monthly, seasonal, and yearly amounts of rainfall for the period 1894 to 1905 from the records of 890 stations. Extrapolation was necessary where the observations were incomplete. The peninsula can be divided into two parts, according as the annual rainfall is greater or less than 1000 mm. The smaller area to the west has a fall of more than 1000 mm., the bounding isohyetal of 1000 mm. running in a NW.-SE. direction from NW. Croatia to the Gulf of Corinth. In an area near the Gulf of Fiume annual rainfall exceeds 2000 mm., while near the Bight of Cattaro, west of Montenegro, there is an annual total of 4700 mm., this being the wettest district of Middle Europe. Round about Constanza and Varna on the Black Sea the annual total is less than 500 mm. As usual the isohyets run closely parallel to the contour lines. As regards seasonal variation the western side has a prominent minimum in summer, when south of Corfu that district is rainless. Winter on the western side is the wet season, the south being wetter than the north. The continental part of the district, comprising Bosnia, Servia, and Bulgaria, has a prominent summer maximum. The east side has a summer maximum in the north and a double maximum (summer and winter) on the coast of the Black Sea. In Greece the maxima occur in autumn or winter. The number of rain days has a maximum in the spring. The max. summer rainfall of the interior is caused by heavy thunderstorms. The rainiest months are Dec. (in the Mediterranean region) and June (in the north), the transition between the two being effected gradually. R. C

769. *Indications of the Seismograph at the Central Office of Meteorology and Geodynamics at Rome.* G. Agamennone. (Accad. Lincei, Atti, 22. pp. 175-179, Feb. 2, 1918.)—Tacchini has previously communicated the effects of mine and powder-mill explosions on this instrument, and it seemed not less interesting to record the effects produced by the shock of the fall of a heavy wall. The author's minute inquiries elicited the information that this shock which occurred on the morning of Jan. 8, 1918, or its reflection, was felt by persons all over an area of radius 850 m., or about 400,000 sq. m. The seismograph was at about 700 m. distance, double the extreme distance at which the shock was perceptible to the human senses, but nevertheless did not fail to register distinctly the passage of the waves through the soil over it. The commencement of the disturbance was at 4h. 25m. 14s. \pm 2s., the first waves having a periodicity of about 1 sec., shortly succeeded by more rapid ones (0.8 sec.). Towards the NE. the first maximum had an amplitude of 0.1 mm. at 4h. 25m. 16s., followed by another at 4h. 25m. 17s., and the vibrations continued till 4h. 15m. 87s. On the NW. the max. amplitude (0.15 mm.) was at 4h. 25m. 17s., after which the movement rapidly diminished, the waves having at first a period of 0.6 sec., then more slowly and of periodicity 1 sec. till the end 4h. 25m. 87s. Thus the actual movement of the ground must have been very small, the amplification of the seismograph being 80 times, the values 0.1, 0.15 mm. giving 0.008 and 0.005 mm. as the true movements in the respective directions at the distance of the observatory. The maximum phase occurring at 2-8 secs. after the commencement indicates the proximity of the disturbance. The short period of the waves corresponds with those produced by the passage of a heavy vehicle some hours afterwards on the same day, giving rise to waves of period $\frac{1}{2}$ sec. or so. For true seismic shocks arising in the vicinity and registered by the instrument the period is generally about 1 sec. and rarely less. Thus it must be admitted that the only cause of the disturbances registered was the fall of this heavy wall, of weight about 8000 tons, which, thrown down all at once upon the ground, propagated all round a very strong shock.

F. W. H.

770. *Influence of Pressure-variations on the Weather in Austria North of the Alps.* O. v. Myrbach-Rheinfeld. (Meteorolog. Zeitschr. 80. pp. 18-28, Jan., 1918.)—A numerical value is assigned to the weather of each day, account being taken of cloud and precipitation only. The scale is drawn up from the consideration that the cause which usually produces cloud, namely, ascent of air, when carried far enough, produces also precipitation; and it is made continuous, starting from clear sky and passing through cloudy sky, overcast and showery, to long-continued and heavy rain. The change of pressure from one morning to the next, *i.e.* the values from which isalobaric maps for a 24-hour time interval are prepared, are also determined for each day, and curves are drawn showing the course of the weather throughout each month and the corresponding pressure-changes. It is found that, for the region considered, bad weather is associated with a simultaneous *increase* in pressure, and good weather with a *decrease*, the variations being roughly proportional to one another. The influence of pressure itself, as distinguished from change of pressure, is superposed upon this effect, especially for the high-pressure conditions of anticyclones. The first result is the opposite of that found for more level countries, and is accounted for by the Alpine chain, which causes the NW. winds of a region of rising pressure to ascend, so that bad weather is produced; while the SW. wind of a region of falling pressure is a descending one, and the weather in the locality is therefore dry and fine.

R. C.

771. Observations of the Neutral Points of Atmospheric Polarisation. C. Dorno. (*Meteorolog. Zeitschr.* 80. pp. 71–80, Feb., 1918.)—The observations were made with a Savart's polariscope, and the calculation of the mean values given at the end of the accompanying tables are based only on the results of cloudless days on which the sky showed only trifling deviations from perfect transparency, and so the influence of cloud on these numbers does not require consideration. The first period, Oct., 1911, to May, 1912, gives very small values for the deviation of the Arago point from the "Anti-Solar" point. There are given values also for the respective positions of the Babinet and Brewster point, and more detailed monthly values both from morning and evening observations for all three points. The magnitudes of the deviations of the Babinet and the Brewster points vary somewhat as follows: $Bw > Bb$ from Oct. to Feb. and in September, $Bw < Bb$ in March to May (the clearest months), whilst in general $Bb < Ag$ in Oct. to Dec. and March to May, but $Bb > Ag$ in Jan., Feb., and Sept. A striking result not hitherto met with is the small difference between the Bb and the Ag values. A comparison of some of the author's results with those of Suring, Plassmann, Platania, and Busch is given in a short table, the latter generally showing the smaller values for Bb than for Ag . The effect of the various cloud-forms on the positions of these points is next considered, as also the presence of a remarkable halo on the afternoon of May 4; this was itself positively polarised, but inside there prevailed partly negative polarisation, the neutral lines going above and below through the inner (red) border, the points $Bb < Bw$ lying in the red. With regard to the polarisation of the clouds themselves, the clearest stratus and cirro-stratus were in general unpolarised, and probably also the cirrus and alto-cumulus for the small traces of polarisation observed were no doubt due to small patches of intervening blue sky. As for the fracto-cumulus clouds, the author still leaves open the question as to their polarisation.

F. W. H.

772. The Absorption of Light in the Atmosphere. G. Müller. [Review by A. Defant.] (*Meteorolog. Zeitschr.* 29. pp. 511–516, Nov., 1912.)—Observations of light intensity according to different wave-lengths of the spectrum were made in the spring of 1910 at altitudes of 100, 1950, and 3260 m. in the island of Teneriffe, by means of the Glan-Vogel spectral photometer of the Potsdam Observatory, to determine the coefficient of transmission of the atmosphere as derived from the Bouguer-Pouillet formula. Curves are plotted giving the relation between coefficient of transmission and wave-length at each level, and curves already obtained for Washington, Potsdam, Mount Wilson, and Mount Whitney are added for comparison. The curves are very similar to one another, the coefficient being relatively low for low wave-lengths and high for high wave-lengths. The mean coefficient naturally increases with increasing altitude of the station, and at the highest stations (over 8000 m.) only 4 per cent. of red rays is absorbed. All the curves, except that for Mount Whitney (4420 m.), exhibit an inflection at $\lambda 0.570$ to $\lambda 0.580$, indicating selective absorption of the green rays, and it is therefore supposed that this phenomenon is confined to the lower layers up to about 8500 m.

The absolute temperature of the sun is deduced, both from Wien's and Planck's formulæ, to be about 6800° abs.

R. C.

773. Condensation Nuclei in the Atmosphere. A. Wigand. (*Meteorolog. Zeitschr.* 80. pp. 10–18, Jan., 1918.)—It is known that nuclei are necessary for
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condensation, and that the forces which cause water-vapour to condense on them are either molecular, including physical adsorption and chemical absorption, or electrical, as when the condensation takes place on ions. Physical forces include surface-tension effects whereby water is more freely condensed on surfaces having small curvature than on those with large curvature; chemical forces include those producing condensation on hygroscopic substances; while the electrical forces favour condensation on small drops, but not on large ones, for the same charge. The amount of the so-called "dust" upon which condensation takes place can be determined by means of Aitken's dust-counter, and the number of nuclei per c.cm. thus computed, but the nature of the "dust" has been little investigated. The author carried out experiments to show that ordinary dust, such as that from a carpet or from coal, does not readily form nuclei; but, on the other hand, smoke from a cigarette or a petroleum lamp provides an infinite number of nuclei. Pure carbon dioxide, however, does not contain favourable nuclei. It is probable that smoke contains SO_2 and other hygroscopic gases, but it is known that ions are produced when a flame burns, and condensation may take place on these, provided they are the so-called "large" ions of low mobility, and not the "small" ions which are the usual objects of observation in measurements of atmospheric electricity. The author suggests that haze, which is known to be electrically charged, and to provide favourable nuclei for condensation, is composed largely of matter which is similar to the large ions produced during the burning process.

R. C.

774. Results of Unmanned Balloon Ascents in the North Polar Regions. H. Maurice. (Comptes Rendus, 156. pp. 788-741, March 8, 1918.)—The earliest results obtained by Teisserenc de Bort and Hildebrandsson were published in 1907. Since then two other series of observations have been made in the same district in 1908 and 1909, and some of the balloons sent up in 1907 have been recovered later. All the balloons were sent up from Kiruna, lat. $67^\circ 50' \text{ N.}$, and long. $17^\circ 54' \text{ E.}$ (of Paris), at an altitude of 500 m. above sea-level. Seventy-two balloons in all were sent up, 41 of which were recovered, and 89 of these have given available results (15 of 1907, 16 of 1908, and 8 of 1909). The greatest height reached was 22,760 m. on Feb. 24, 1908, and the lowest temperature was -75.6° at 11,110 m. on Feb. 18, 1909. A table showing some of the principal results is given in the paper. Most of the balloons were recovered to the east of Kiruna, thus showing the predominance of west winds in the upper regions, confirming the polar vortex theory of Ferrel and the earlier observations of lofty clouds. But the balloons sent up on the coldest winter days always fell very near Kiruna, and often a little to the west of it. All the balloons showed that above a certain height the vertical [temperature] gradient vanishes or is very small, and often negative; above [this altitude] the temperature only shows very slight irregular changes. This layer was consequently named the isothermal layer, or *stratosphere*, by Teisserenc de Bort, who was the first to demonstrate its existence in the temperate zone. In our latitudes this layer is met with at an altitude varying from 7000 to 12,000 m., and its temperature varies from 45° to 60° C. , whilst near the equator it is not found lower than about 15,000 m. or 17,000 m., and its temperature is not far from -85° . In Lapland but little seasonal variations seem to occur; the summer and winter ascents give but little different results, and the temperatures in the upper air "depend rather on the general meteorological condition than the season of the year." Comparison of balloon observations made simultaneously at Kiruna

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and at Trappes in France show that the isothermal layer is at a lower level in the former region than the latter (9800 m., temp. -49° Kiruna ; 12,000 m. and -65° Trappes). At greater heights there is but little difference, though on the whole the more northerly station gives higher temperatures. Finally, comparing the results of balloon ascents made in different regions of the globe, we arrive at the somewhat unexpected result that at a very great height (such as 16,000 m.) we get a temperature of -50° to -60° in the circumpolar and temperate zones and -80° at the equator, exactly opposite to the temperature variations of the surface, which seems to indicate that the thickness of the atmospheric layers in which the vertical movements of the air take place is much greater in the equatorial regions than anywhere else.

F. W. H.

775. *Icebergs and the Temperature of Sea-water.* J. Aitken. (Nature, 90, pp. 518-515, Jan. 9, 1918.)—Some of the statements made by Barnes in his two papers [see Abstracts Nos. 1010 (1912) and 194 (1918)] being apparently incompatible, the author, referring to the researches on oceanic circulation by Carpenter (1878) and himself, describes some novel experiments. He moors a lump or rod of ice (from air-free water, coloured blue with aniline) in salt water; the blue ice-water rises to the surface, but does not sink at all; Barnes had withdrawn his statement that he believed in a rising current of ice-water. Aitken then drew a blue line in the water above the ice by passing a pipette with a capillary end, charged with blue salt water, horizontally through the water. The melting ice deflected this line upward close to the ice, but downward further away. Thus the fused ice-water kept close to the ice, and a cold downward current was set up further away. The appearance was not changed when a long rod of ice was placed in a deep vessel (1 ft.) which was cooled in its lower portions. Experiments on a large scale are needed. **H. T. Barnes.** (Nature, 90, pp. 671-678, Feb. 20, 1918.)—Referring to his letter of Dec., 1912 [see Abstract No. 194 (1918)], Barnes reproduces the micro-thermogram which he obtained in June, 1912, when he crossed the Atlantic from Europe via North of Ireland and Cape Race. The temperature of 9 or 10° C. dropped to 7° when they passed the "Cold Wall" between Gulf Stream and Arctic current and went down further to 4° , but rose again from 5° to $6\frac{1}{4}^{\circ}$ in the neighbourhood of an iceberg. There was very little evidence of dilution of the sea-water by the ice-water, because the melting was slow; sea-water conductivities taken in July, 1912, at 26° C. fluctuated between 0.0477 and 0.05 without showing any regular influence of icebergs. East of the Straits of Belle Isle the conductivity rose in Oct., 1912, at 25° , rapidly for the first 180 miles, from 0.0486 to 0.052, and kept then nearly constant up to 450 miles. The great Arctic current seems to be of a lower order of salinity. There is no reply to Aitken.

H. B.

776. *Seiches of Lake Inawasiro.* (Mathematico-Physical Soc., Tōkyō, Proc. 7, pp. 24-29, Feb., 1918.)—The lake lies 570 m. above sea-level; it is surrounded by steep mountains and fairly regular in shape, 12 by 10 km.; the mean depth is 51 m., the max. depth 112 m. The observations were made by students of Tokohu University under Honda and with his instruments. Oscillations were observed of two periods, 19.11 and 8.89 mins. Oscillations in a model of the lake, scales 1 : 25,000 and 12 : 10,000 (length and depth), were produced by a vibrating vertical rod; the periods deduced from these experiments would be 19.58 and 9.11 mins. There seem to be

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three nodal lines. As regards the origin of the seiches, it is suggested that the wind heaps up the water in certain parts; when the wind decreases or changes its direction, the water returns and causes seiche oscillations.

H. B.

777. *Seiches of Lake Tōya*. K. Sano. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 17-22, Jan., 1918.)—In 1905 Honda obtained a period of 9.29 mins. from his observations of this lake, the calculated period from Marian's formula being 11.2 mins. Had allowance been made for the presence of the island at the centre of the lake better values would have been obtained; but the present author, calculating the period on a different hypothesis from that assumed by Honda, found a closer agreement between the calculated and observed period. The lake is nearly circular in form, and has an island also circular in form and almost concentric with it, so that we may consider the water to be contained between two coaxial cylindrical surfaces with vertical axis, the mean depth being 9.58×10^3 cm. If a and b be the external and internal radii and h the depth, we have $a = 5 \times 10^3$ cm., $b = 1.2 \times 10^3$ cm., $h = 9.58 \times 10^3$. Figures are given showing the nodal lines where the vertical component velocities of the water vanish in different assumptions, and the possible periods of oscillation are calculated. Instead of Honda's value, the author obtains a period of 10.24 mins., being greater than that observed by about 10%. A shorter period observed by Mori in 1911, 4.5 mins., may correspond to one of the other possible modes of oscillation (8.9 or 3.4 mins.), but may be due to a change of depth in the water of the lake.

F. W. H.

778. *Production of Stationary Tides of the Second Order in an Ocean possessing any Law of Depth*. E. Fichot. (Comptes Rendus, 156. pp. 211-218, Jan. 20, 1918.)—The author discusses a previous paper by Rayleigh [see Abstract No. 1155 (1908)]. The conclusion drawn is that nothing will oppose the production of a stationary tide of the second order, whose deviation from the tide proper varies with the extent of the permanent circulation areas, and it will depend on the law of depth and the continental distribution.

H. H. Ho.

779. *An Important Problem in Cosmical Physics*. C. Störmer. (Comptes Rendus, 156. pp. 450-458, Feb. 10, 1918.)—The author gives further results [see Abstracts Nos. 1827 (1911), 868 (1918)] on the problem of finding the motion of an electrified corpuscle in the field of a simple magnet, by supposing that the corpuscle is subjected to the action of a central force emanating from the magnet and inversely proportional to the square of the distance. From the equations developed the trajectories of the particles, equipotential lines, and points of equilibrium are discussed, and a series of interesting consequences deduced.

H. H. Ho.

780. *A Mechanical Problem and its Applications in Cosmical Physics*. C. Störmer. (Comptes Rendus, 156. pp. 586-589, Feb. 17, 1918.)—A previous investigation [see preceding Abstract] on the trajectories of electrified corpuscles in a simple magnetic field is shown capable of a mechanical interpretation very useful for the study of trajectories. Applications are made to Arrhenius' theory of the aurora borealis, in which he supposes that material particles are ejected from the sun by radiation-pressure; to the theory of the solar corona; and to Birkeland's ideas upon the zodiacal light, comets, Saturn's rings and cosmogony. [Errata, p. 926, March 17, 1918.]

H. H. Ho.

781. Detection of General Magnetic Field of the Sun. G. E. Hale. (*Terrestrial Magnetism*, 17. pp. 178-178, Dec., 1912.)—In 1908, shortly after magnetic fields had been detected in sun-spots, attempts were made at the Mount Wilson Solar Observatory to observe the Zeeman-effect due to the general magnetic field of the sun. The investigation was resumed in 1911, and in 1912 with the greater power of the 150-ft. tower telescope and 75-ft. spectrograph. The dispersion was 4.9 mm. to the Ångström unit, using the third order of a large Michelson diffraction grating. A Nicol prism was placed in front of the spectrograph slit, in combination with a compound quarter-wave plate made up of sections of mica 2 mm. wide, the principal sections of successive strips making an angle of 45° with the slit and 90° with each other.

A series of photographs of the spectrum near the D lines were made with the third order, and with the slit adjusted to various latitudes on the central meridian of the sun. With very few exceptions the resulting measurements of the displacements of the lines showed that these were positive in the northern and negative in the southern hemisphere, their magnitude decreasing from a maximum near 50° north or south latitude, to zero near the equator. A marked feature of the observations lay in the fact that only a few of the solar lines appeared to be thus affected, the others showing no shifts, although they were known to give large Zeeman-effects in the laboratory. This may be due to differences of level in the solar atmosphere. Another series of observations is in progress, using a solar image $16\frac{1}{2}$ in. in diam.

C. P. B.

782. Integrated Spectrum of Milky Way. E. A. Fath. (*Astrophys. Journ.* 86. pp. 862-867, Dec., 1912. Contribution from the Mount Wilson Solar Observatory, No. 68.)—The results of the Harvard spectroscopic survey indicate that over 52 % of the 82,000 stellar spectra already investigated belong to the A type, and that the ratio of A-type stars to all other types increases as the brightness decreases. Two-thirds of the stars investigated in the Milky Way are of the A type. The present note gives the result of an investigation of the integrated spectrum of the Milky Way, undertaken at the Mount Wilson Observatory with a special spectrograph. Exposures of from 80 to 74 hours were given, and the resulting photographs indicate that the spectrum of the integrated light from various regions of the Galaxy is approximately of the solar type. The G group of lines is faintly indicated, and the strong calcium absorption lines H and K, with several bands further towards the ultra-violet.

C. P. B.

783. Relation between the Spectra and other Characteristics of the Stars. H. N. Russell. (*Amer. Philosoph. Soc., Proc.* 51. pp. 569-579, Oct.-Nov., 1912.)—The absolute magnitude of stars is taken as the stellar magnitude they would appear to have if each star was brought to the standard distance of 82 light years (parallax of $0.10''$). Such absolute magnitudes, when plotted against the spectral types, show that most of the stars belong to a series in which the fainter are redder than the brighter, while a few outstanding stars of each spectral class greatly exceed in brightness those belonging to this series. Hertzsprung has called these "dwarf" and "giant" stars. The relation between absolute magnitude and spectral type appears to be independent of the origin of the particular star or group under consideration, and can be represented by $\text{Abs. Mag.} = 0.5 - 2.2(\text{Sp.} - \text{A})$, in which the spectrum B is counted as 0, A as 1, F as 2, etc. Of 218 stars with fairly

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reliable parallax and spectrum determinations, 69 % have an absolute magnitude within one of that computed by this formula. First magnitude giant stars, not included in above consideration, can be seen at enormous distances, and consequently form a disproportionate part of the stars visible to the eye; few are near enough for reliable parallax measurements. The respects in which giant and dwarf stars differ, besides in brightness, are considered in binary stars, with orbital elements and apparent brightness known; the ratio L^2/M^2 (L = combined light; M , combined mass) can be determined without knowing the parallax. The author has, by statistical methods, extended this principle to stars physically connected, but whose orbits cannot be computed. Three hundred and fifty stars have been so investigated, and found to fall into two series of high and low luminosity per unit mass respectively. In these the mean absolute magnitudes agree almost perfectly with those derived for other groups. The author concludes that a "B" class star is 8 to 4 times the sun's diameter, 15 times his area, 200 times as bright, and therefore 15 times his surface brightness. Similarly, "A" class stars have a surface intensity of 5 times the sun's. Faint stars of classes "K5" and "M" average only 1/100th of the sun's light, with masses exceeding half the sun's; such diminution of surface brightness with increased redness, proved in the dwarf stars, supports the hypothesis that spectral class differences are due to surface temperature differences, and this also applies to giant stars. The latter, nearly equal in brightness for all spectral types, must decrease very rapidly in density with increasing redness. If stars are arranged in order of increasing density, the series begins with giant stars of class "M," passes through giant series to "B," then through the dwarf stars to the faint red. This agrees with the theoretical behaviour of masses of stellar gas left to gravity and radiation. The highest temperature will be attained at a density for which the departures from the gas laws are considerable, but probably before the density is as great as water. "B" and "A" class stars (the hottest) are found to have one-fifth the density of water. The author's hypothesis is that giant and dwarf stars represent different stages in stellar evolution, the former being young stars growing hotter, and the latter old stars growing colder and redder. H. F. H.

784. *Observations of RCygni near Minimum.* T. E. Espin. (Roy. Astronom. Soc., M.N. 78. pp. 164-165, Jan., 1918.)—Observations were made during the minimum of this interesting variable, 1912 Sept. 2-Nov. 29, with a small spectroscope of low dispersion capable of showing the spectrum of Nova Lacertæ when only 12th mag. Examination of the star disc with high powers failed to show any signs of nebulosity. C. P. B.

785. *Motions and Distances of Bright Stars.* H. C. Plummer. (Roy. Astronom. Soc., M.N. 78. pp. 174-191, Jan., 1918.)—In a former paper attention was drawn to the probability of certain star groups (Class A) moving nearly parallel to the plane of the Milky Way. The present paper deals with the study of the stars of class (B—Bs) from a similar point of view. The general conclusion is that the stars of Secchi's type I, with apparent magnitudes 3, 4, and 5, considered as a whole, are very thoroughly distributed in space. The results are discussed in relation to Schwarzschild's ellipsoidal hypothesis. C. P. B.

LIGHT.

786. Prism Spectrograph. P. Weiss and R. Fortrat. (*Archives des Sciences*, 85. pp. 5-27, Jan. 15, 1918.)—Describes two similar spectrographs, one having flint-glass prisms, the other quartz prisms, both instruments having high resolving power. The principle of autocollimation is employed. Light from a narrow slit is reflected by a total-reflection prism on to a concave mirror; this mirror renders the light parallel and sends it through a train of five prisms, whose refracting angles are about 68° , and through a right-angled prism of half this angle, whose back face is silvered, thus causing the light to return through all the prisms to the mirror, which focusses the light on the photographic plate. The dispersion, therefore, is equal to that obtained with eleven prisms. The prisms are mounted on a Hamy train, ensuring the equality of the angles between the faces of consecutive prisms when they are turned; hence a ray traversing the first prism at minimum deviation traverses all the others under the same condition. Special features of the apparatus, such as the position of the slit, the separating power, the loss of light by reflection, and the optical properties of the glass used for the prisms, are discussed at length. In the quartz prism instrument a quartz lens was used instead of the concave mirror. The quartz prisms were cut with the optic axis parallel to the refracting edge, a method suggested by A. Cotton, and the refracting angles varied from $64^\circ 55' 15''$ to $65^\circ 2' 30''$. A table is given comparing the dispersions obtained with other spectrographs. Many studies of band spectra and of the Zeeman-effect in absolute measure have been made with the instrument. With long exposures lines have been photographed whose feeble intensity renders it impossible to study them with a grating. Among others, important new lines have been observed in the very faint violet band of the Swan spectrum. A. W.

787. New Application of Röntgen Rays: Micro-radiography. P. Goby. (*Comptes Rendus*, 156. pp. 686-688, March 8, 1918.)—Describes, with diagrams and constructional details, an apparatus by means of which radiograms of microscopic objects, such as diatoms, foraminifera, etc., may be obtained with such sharpness that they may be enlarged 15 or 20 times with little loss of definition, and hence the internal structure of the objects may be easily studied. A. W.

788. Radiometer Attachment for Monochromatic Illuminator. W. W. Coblenz. (*Frank. Inst., Journ.* 175. pp. 151-152, Feb., 1918.)—In cases where the effect of light-stimuli is being investigated it is desirable to know the energy value (mechanical equivalent) of the different wave-lengths employed, and it is usually desirable to reduce the energy of the different spectral regions to the same value. For this purpose it is necessary to use a radiometer whose working is independent of the frequency of the stimulus. The most useful radiometer which requires but little care is a thermopile. The Bi-Ag thermopile is much more sensitive than an iron-constantan one. In the present case it is mounted securely in an air-tight metal box fitted with a quartz window. The diam. of the Bi-wire is 0.1 mm., and that of the Ag-wire 0.04 mm. The metal case moves in a vertical slide in front of the

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spectrometer slit, so that it can be brought in front of the slit or be raised above it at will. The thermopile is connected to a galvanometer whose readings will be a measure of the energy of the light falling on the junctions. The apparatus is being made by Hilger. A. W.

789. "Cellit." A Non-inflammable Cinematograph Film. C. R. Hennings. (Photographic Journ. 58. pp. 10-18; Discussion, pp. 18-14, Jan., 1918.)—The celluloid of the ordinary cinematograph film is a compound of nitro-cellulose and camphor. It is highly combustible, burning rapidly and in such a manner as to quickly involve surrounding objects, while the gases evolved, which include carbon monoxide, oxide of nitrogen, and hydrocyanic acid are highly poisonous. On the other hand, the "cellit" film is practically non-inflammable, and, so far as the adhesion of the emulsion and the suppleness of the base are concerned, the two types of film are identical. It is almost impossible to distinguish the two by mere outward appearance. "Cellit," however, expands more than ordinary film in developing, fixing, etc., the expansion with celluloid being 0·8 %, with "cellit" 1·2 %. The film after drying assumes its original size, and no shrinkage, such as would lead to inaccuracy in the perforations, occurs with several months' storage. The new film is developed, fixed, and washed in the same manner as the celluloid film, and the pictures are identical and may be coloured in a similar way. A. E. G.

790. Formation of Mirrors by Scattering due to Kathode Rays. G. Rümelin. (Phys. Zeitschr. 18. pp. 1222-1228, Dec. 15, 1912.)—A description is given of apparatus suitable for quickly obtaining a thin film of metal by scattering produced by kathode rays. This is a most convenient manner of forming thin layers of different metals for the purpose of studying their optical properties. A. E. G.

791. Absorption Curves of Colloidal Silver Solutions. R. Gans. (Phys. Zeitschr. 18. pp. 1185-1186, Dec. 15, 1912.)—The author has recently shown [Abstract No. 1828 (1912)] that the ultra-microscopic particles in colloidal gold solutions must be of nearly spherical form. He is now investigating the form of the particles of a silver solution, and by way of preliminary gives the calculated absorption curves corresponding to twelve different assumed forms of the particles. The absorption curve is seen to depend largely on the form of the particle. Hence, when the measures necessary to obtain the actual absorption curve are concluded, it should be possible to deduce from them the required form. In making the calculations, data given by E. Müller [Abstract No. 1857 (1911)] were used, and the particles were assumed to be ellipsoids of rotation infinitely small compared to the wave-length of light. The twelve values assumed for the ratio of axes include the values 0 and 1, covering the cases of sphere, disc, and rod. A. E.

792. Refractive Index Determinations with the Microscope. H. E. Merwin. (Washington Acad. Sci., Journ. 8. pp. 85-40, Jan. 19, 1918.)—Various immersion liquids have been in use for the determination of refractive indices over the interval 1·88 to 1·90; mixtures of amorphous sulphur and selenium have been found useful over the range (for sodium light) 2·1 to 2·4. In the present paper immersion media are described to fill the gap 1·90 to 2·10, and to extend the series beyond 2·4, or in special cases, particularly when a refractometer is not at hand for standardising the liquids, take the place

of media hitherto used. For the latter purpose solids have been found which may be mixed in given proportions by weight to produce permanent standard media. These are either vitreous (more or less rigid) or liquid (fluid). For details the original paper should be consulted. A. W.

793. Double Refraction produced by Distortion of Elastic Bodies, according to Volterra's Theory. O. M. Corbino. (Nature, 90. pp. 540-541, Jan. 16, 1918).—A republication of researches by the author and G. C. Trabacchi, hitherto only published in Italy [Abstract No. 1159 (1909)], in which it is shown how, starting from Volterra's general formulæ, the double refraction produced by distortion of a cylindrical ring of elastic substance, in which a radial or parallel slot has been cut, and the cut surfaces then glued together, may be mathematically deduced, and such deductions experimentally verified. Photographs of the various effects obtained are reproduced. W. H. St.

794. Limits of Application of Polarisation Photometers to Investigations on Diffusely Reflecting Surfaces. V. Návrát. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1289-1296, July, 1912).—The author discusses the extent to which "shiny" reflection from a so-called matt surface may lead to polarisation, and hence exclude the use of polarisation photometers for studying the intensity of light reflected therefrom. Previous investigations show that the effect is more pronounced when the light strikes the surface at an oblique angle, and when the material is coloured [see Abstract No. 666 (1912)]. Some detailed numerical experiments on this point are described, and the results collected in tabular form. These show that true diffused reflection is characteristic of surfaces which consist of permeable cloudy media. In order that such directly reflected light as exists may be practically unpolarised the angle between the incident and reflected ray should be as small as possible, preferably within 10° . In the case of plates composed of compressed powder, and presenting surfaces the size of the particles on which is large compared with the wave-length of light, polarisation is to a great extent suppressed and the safe angle of inclination may be increased somewhat. J. S. D.

795. Non-focal Images of Gratings. M. Wolfke. (Ann. d. Physik, 40. 1. pp. 194-200, Dec. 31, 1912).—Discusses some experiments which show that Abbe's theory of diffraction images requires revision. In the general case, when several chief maxima come into operation, the image is distinctly affected by a displacement in the direction of the principal axis. The original image returns in all positions distant from the focal plane by a multiple of γ^2/λ , where γ is the element of the grating and λ the wave-length. The greater the distance from the focal plane the less distinct is the image, but the fringes are distinctly seen even at a distance of $4\gamma^2/\lambda$. A new derivation of the image equations, rendered necessary by these observations, is given. [See Abstracts Nos. 616, 1474 (1911).] E. E. F.

796. Optical Constants of Certain Metals in the Infra-red. K. Försterling and V. Fréedericksz. (Ann. d. Physik, 40. 2. pp. 201-282, Feb. 4, 1918).—Using a Wadsworth monochromator and a polarisation spectrometer in conjunction with a bolometer, the optical constants were determined for Ag, Cu, Au, Pt, and Ir. The results are tabulated and graphed, and theory given, the experimental and calculated results being in good agreement, though some discrepancies are noted. A. W.

797. *Molecular Impact and the Emission of Light.* H. Pettersson. (Phys. Zeitschr. 14. pp. 109–112, Feb. 1, 1913.)—It is assumed that the state of vibration of a resonator varies with the time elapsed since collision. Immediately after collision the vibration is irregular, like that of white light. Most of the components are strongly damped, but those corresponding to the proper frequencies of the resonator gradually emerge and finally survive the others. When the time between collisions is long, as in rarefied gases, the proper frequencies are the only ones which give a measurable effect. This observable emission and absorption thus depends upon the frequency of molecular impact, and certain phenomena lately discovered by Ångström, v. Baur, and Wood may be explained on these lines. E. E. F.

798. *Rod Vision.* O. Lummer. (Phys. Zeitschr. 14. pp. 97–102, Feb. 1, 1913.)—Quotes some observations to show that on a clear star-light night vision is chiefly a function of the rods, and is therefore colour-blind. Most stars are seen by indirect vision. The Pleiades when looked at straight shrink to a few points of feeble luminosity, whereas they produce a bright silver-white image when seen with the circumfoveal areas of the retina. An accurate knowledge of the curves of visual intensity in the spectrum has only become possible by the realisation of the ideal black body, and with the help of the spectrum flicker photometer. The maximum of sensitiveness is a wave-length 5550 for the cones and at 5150 for the rods. The observations quoted were made in a balloon voyage in the full moonlight and during a stay in the Iser Mountains. Stars with a “rod-white” luminosity could be made to disappear by bringing the colour-discriminating cones into activity. Their disappearance was often marked by scintillation or by sudden displacements. E. E. F.

799. *Projection of Natural Colours.* A. Guéhard. (Comptes Rendus, 156. pp. 127–129, Jan. 18, 1913.)—A paper discussing the theoretical possibility of obtaining a reversible arrangement for the automatic reconstitution of the natural colours of objects in projection. A. W.

800. *Electric and Magnetic Double Refraction.* II. and III. W. Voigt. (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 7. pp. 882–848, and pp. 861–878, 1912.)—A theoretical treatment with special reference to the anomalous dispersion and absorption lines [see Abstract No. 66 (1913)]. E. H. B.

801. *Resonance Spectra of Iodine by Multiple Excitation.* R. W. Wood. (Phil. Mag. 24. pp. 678–698, Oct., 1912. Phys. Zeitschr. 14. pp. 177–189, March 1, 1913.)—In previous work the spectra excited by many widely separated wave-lengths have been studied [see Abstract No. 42 (1912)], but the author came to the conclusion that no great advance could be made until some method was devised for varying the wave-length of the exciting light by very small amounts. A step has now been made in that direction, and some surprising results have been obtained which throw light on some points hitherto difficult to explain. The resonance spectrum suffers profound changes when small changes occur in the structure of the exciting line. The complexity of the iodine absorption spectrum has been greatly underestimated. Every increase in resolving power brings more structure into view, and the elaborate maps and tables of wave-lengths which have been published from time to time are absolutely worthless. For instance, seven

sharp absorption lines of iodine are now found *within* the green mercury line emitted by the quartz mercury arc, where there is only a single line on Hasselberg's great map of the iodine spectrum. In one of the yellow mercury lines 14 absorption lines are found, and 12 in the other. When, therefore, the resonance spectrum is excited by one or other of these lines, from 7 to 14 different frequencies may respond to what might be called monochromatic excitation. It becomes at once clear why a small change in the distribution of intensity in the exciting line or in its structure may modify the resonance spectrum. The author has even succeeded in modifying the structure by the use of ray filters which remove certain frequencies from the exciting line: *e.g.* by passing the green light from the mercury arc through bromine vapour before it enters the iodine vapour a change can be produced in the resonance spectrum excited by the green mercury line. The same method could doubtless be applied to the sodium resonance spectrum, but the iodine vapour is very much easier to handle. The resonance spectra, as a whole, was photographed with a large 8-prism spectrograph, and for studying the structure of the resonance lines themselves, as affected by the structure of the exciting line, a concave grating was employed. The absorption for frequencies falling within the spectral range covered by the exciting rays was studied first with a 6-in. plane grating in the 4th order spectrum used with a spectrometer of over 2 m. focus, and afterwards with a 40-ft. spectrograph. This spectrograph is the most powerful in the world, except possibly Michelson's 10-in. grating instrument. It was put together out of odds and ends. The piers were improvised from two 6-in. water mains slightly damaged by frost. The plate-holder and slit are supported on a shorter piece of water-pipe. The camera consists of two wooden boxes, one sliding within the other, joined to the end of the tube by black cloth, which does not transmit vibration. The long tube was made by nailing 8-in. boards together. The mercury arc was employed as a source of light. The plane grating gave a resolving power of 800,000 in the 4th order.

The absorption spectrum of iodine, which has a general resemblance to the channelled absorption of sodium vapour, presents a wonderful appearance in the large spectrograph, nearly the entire visible spectrum being filled with thousands of lines, probably over 50,000. Comparison of a portion of the absorption spectrum with the corresponding portion of Hasselberg's map shows that Hasselberg's lines mean nothing beyond indicating roughly the position of some of the groups of lines. "A study of these two pictures cannot but furnish food for thought to astronomers working at the problem of the canals on Mars." The absorption of sodium is equally complex. Sodium, however, exhibits only a single faint line within the green mercury line; hence the mercury arc is incapable of stimulating sodium vapour to appreciable fluorescence. A large number of lines in the absorption spectra of bromine and iodine coincide. There appear to be more coincidences than can result from accident, and the author suggests that there may possibly exist in the two elements identical systems of electrons which give rise to similar frequencies in the two molecules. The iodine absorption spectrum observed with sunlight is far superior to the solar spectrum for testing large gratings. The author has succeeded, by the use of filters, in separating the resonance spectrum of iodine due to the green mercury line from that due to the two yellow lines. With fairly high dispersion, the lines excited by the green ray are seen to be in reality close doublets accompanied by fainter companions. The series seen consists of 25 pairs, two of which are missing. Certain lines were found to be missing in the resonance spectrum of sodium

vapour, and this peculiarity is probably characteristic of all resonance spectra. The law of spacing is not the same for iodine and sodium. For sodium the wave-length intervals, but for iodine the frequency-differences, are approximately constant. They are not strictly constant, however, and it seems possible that the discrepancies may be the result of slight perturbations which modify the periods. The wave-lengths were determined from photographs. Under high resolving power a very complicated structure is found, which appears to be a result of multiplex excitation, *i.e.* excitation by lines broad enough to excite a number of adjacent frequencies. The general appearance of the groups of resonance lines is like a highly (80-fold) magnified image of the group of absorption lines falling within the green mercury line. The author was at first inclined to think that each line in a resonance group resulted from the stimulation of a definite absorption line, but no longer believes so. The component lines accompanying the doublets are quite different for the Cooper Hewitt commercial glass lamp and for the mercury arc in quartz. The strong doublets are shifted towards the violet in the case of excitation by the latter high-temperature arc; it is not an actual shift, but merely a change in distribution of intensity among the lines forming the groups. In addition to this certain lines appear in one case which are absent in the other. A further study of the remarkable transformation of the resonance spectrum into the band spectrum, which occurs when the iodine vapour is in helium at a pressure of a few mm., has been made. The other gases of the He group behave in the same way, and the band spectrum can be brought out by the presence of the air at 1 or 2 mm., though the intensity of fluorescence is enormously weakened. In previous work the fluorescence of mercury vapour was found to be destroyed by raising the temperature of the quartz flask with a blast-lamp. The same thing is true of iodine, which, however, loses its luminosity at a temperature so low that the effect can be shown with a tube of soft glass heated with a small Bunsen flame. A. E.

802. *Arc and Spark Spectrum of Lead.* F. Klein. (Zeitschr. wiss. Phot. 12. pp. 16–80, Feb., 1918. Extract from Dissertation by same author.)—Describes measurements of the lines in the arc and spark spectrum of lead from $\lambda = 7228$ to $\lambda = 2088$ made with a Rowland concave grating, the iron arc being used for a comparison spectrum. Wave-length tables are given in international Å. units to two or three decimal places. A. W.

803. *Arc and Spark Lines in Canal-ray Spectra.* J. Stark. (Phys. Zeitschr. 14. pp. 102–109, Feb. 1, 1918.)—The ratio of the intensity of the spark spectrum lines to that of the arc lines is higher when they are excited by rapid cathode rays (negative glow) than by slow cathode rays (positive light-column at low pressure). The emitters of the spark lines are probably atomic ions of high valency, with a larger number of positive elementary charges than the emitters of the arc lines. One element may thus possess several groups of spark lines, due respectively to bivalent, trivalent, or quadrivalent ions. J. J. Thomson has found that in canal rays in oxygen and nitrogen both univalent and bivalent oxygen and nitrogen ions occur. The difference in the max. velocity of the two species of lines, observed in the canal-ray Doppler-effect, is easily accounted for by the difference in valency n , the velocity acquired being proportional to Vn . E. E. F.

804. *Appearance of Helium and Neon in Vacuum Tubes.* J. N. Collie and H. S. Patterson. (Nature, 90. p. 699, Feb. 27, 1918.)—An examination of
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the spectrum lines characteristic of helium and neon shows that in the secondary spectrum of hydrogen there are a large number of lines very close to the important lines of neon. There are 57 of these differing by less than a quarter of an Ångström unit. Of the six principal Ne lines, five are paralleled in the secondary hydrogen spectrum. There are similar parallelisms between Ne and He. **A. Fowler.** (*Ibid.* 91. pp. 9-10, March 6, 1918).—Fowler points out that there is nothing remarkable in the occurrence of a considerable number of approximate coincidences between lines belonging to the hydrogen and neon spectra respectively, in view of the large number of lines due to both elements in the region referred to. Moreover, a quarter of an Ångström unit is far beyond the limits of error of modern spectroscopy. Of the hundred brightest lines of Ne, only six are found in hydrogen within the probable limits of error, and only one of the six of max. brightness is among them. The helium coincidences are even less suggestive of a connection as the He lines occur in series, and no conclusion could be drawn from an approximate coincidence with isolated lines.

E. E. F.

805. Absorption Spectra of some Uranyl Salts. A. Mazzucchelli and O. G. d'Alceo. (*Accad. Lincei, Atti*, 22. pp. 41-48, Jan. 5, 1918).—Continuing their work on these compounds [Abstract No. 415 (1918)], the authors have compared the absorption spectra of uranous chloride, with and without the addition of an excess of urea, and of uranous chloride and sulphate with and without addition of glycocoll. The presence of urea has no effect on the spectrum, but reproductions of the spectra with and without glycocoll show that the latter has a marked influence, the absorption being greater, especially at the ends of the spectrum.

W. H. St.

806. Zeeman-effect. W. Voigt. (*Ann. d. Physik*, 40. 2. pp. 886-880, Feb. 4, 1918).—The author shows that the Lorentz theory may be modified so as to represent the Zeeman-effect of close triplets and doublets [see Abstract No. 419 (1918)]. He suggests the following substitute for Preston's law: "The characteristic line systems (simple line, doublets, etc.) of one and the same series or of similar series have similar and numerically equal parameters in the (modified Lorentz) magneto-optic equations corresponding to them." If the constituents of the system are separated by a considerably larger interval than the magnetic separations of the simple lines, the formulæ give Zeeman-effects, following Preston's law. If, however, the interval is of the same order or smaller the theory indicates the deviations observed.

J. M.

807. Relative Intensities of Green Hg Line and its Satellites. H. Nagaoka and T. Takamine. (*Mathematico-Physical Soc., Tōkyō, Proc.* 7. pp. 2-10, Jan., 1918).—Describes in detail the method of determining the relative intensities of the satellites of the green Hg line, referred to in the authors' previous paper [Abstract No. 424 (1918)]. Light from a Nernst lamp (110 volts, 1 amp.), placed in a large wooden box, was made parallel by a quartz lens, and passed the photographic plate under examination at normal incidence. The current feeding the lamp was carefully kept constant during the observation. The photographic plate was attached to the end of a short tube which could be moved by a micrometer screw, and the film surface of the plate was almost in contact with the slit (17 mm. × 0.05 mm.). An iron-constantan thermopile of 24 junctions was placed behind the slit and received

the light passing through the slit. A delicate galvanometer was connected to the thermopile and was read when successive displacements equal to the slit width were given to the plate. Special precautions were taken to avoid uncertainty of readings due to temperature-changes of the thermopile case. Several different exposures were necessary; (i) normal exposure for the principal line and strong satellites, the faint lines being mostly under-exposed; (ii) normal exposure for satellites of strong and medium intensity, the principal line being over-exposed; (iii) normal exposure for fainter lines. By successive comparisons of the different plates the relative intensities of the various satellites can be found. Sixty photographs were taken and six selected from these. Tables and diagrams are given showing the results obtained. A. W.

808. Ritz Theory of the Normal Zeeman-effect. K. Körner. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 69-74, Feb. 15, 1918.)—On this theory the Zeeman-effect is the result of the precessional motion of the Ritz oscillators round the direction of the external magnetic field. The author shows that the theory only holds if the angular velocity of the motion $\omega = -\frac{1}{2}(eH/mc)$, where e is the charge of an electron, m the mass, H the field, and c the velocity of light in *vacuo*. This follows from the theory of the top if we assume that the elementary magnets in the Ritz oscillators are rotating negative electrons. J. M.

809. Longitudinal Zeeman-effect. L. de la Rive. (Archives des Sciences, 84. pp. 489-521, Dec., 1912.)—Discusses certain details of the Zeeman-effect, such as the initial conditions in the case of rectilinear polarisation, and the equivalence of Biot-Savart's electrodynamic force and the composite centrifugal force of the electron. It is shown that the magnetic rotation of the plane of polarisation (Faraday-effect) can be explained without having recourse to circular polarisation. Also that natural light, considered as due to two elliptically polarised rays, accords with the Zeeman phenomenon. E. E. F.

810. Chemical Production of Light. W. D. Bancroft. (Frank. Inst., Journ. 175. pp. 129-149, Feb., 1918. Paper read before the 8th Internat. Congress of Applied Chemistry, N.Y., Sept., 1912.)—The author gives a summary of the present state of knowledge regarding the production of light, the conclusions arrived at being briefly as follows:—Photo-, thermo-, pyro-, electro-, kathodo-, anodo-, crystallo-, tribo-, and organo-luminescence are all cases of luminescence due to and accompanied by chemical action, and in some instances of cathodoluminescence it is possible to give the chemical reactions taking place. It is more correct to speak of the spectrum of a reaction than of the spectrum of a substance, and any marked change in a spectrum indicates the occurrence of a new reaction. The same bluish light is emitted when (1) sodium burns slowly in chlorine, (2) sodium chloride is fused, (3) sodium chloride is placed in the surface separating the oxidising and reducing zones of the Bunsen flame, (4) gaseous hydrogen chloride is supplied to a sodium flame, (5) sodium chloride is precipitated from aqueous solution by alcohol or hydrochloric acid, and (6) sodium chloride crystals are crushed. The light effect due to the change from chlorine as ion to undissociated sodium chloride seems at present to be negligible, but more accurate measurements will doubtless show the existence of such effect. Kathode rays excite the bluish luminescence in sodium
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chloride and canal rays the yellow luminescence. Under the influence of cathode rays, potassium iodide emits green light, part of which is probably due to the iodine; it seems possible also that the chlorine may be the cause of some of the white light observed with many chlorides. The experimental evidence is insufficient to show with certainty that the triboluminescence of potassium iodide is the same as the crystalloluminescence and the kathodoluminescence of this salt. All reactions tend to emit light, and do so if the reaction velocity is sufficiently high, and the critical reaction velocity necessary to the emission of light visible to the eye may be very different with different reactions. The intensity of the emitted light increases with increasing reaction velocity, but the quality of the light varies but slightly. The sulphates of sodium, lithium, potassium, zinc, etc., increase the luminescence of cadmium sulphate when exposed to cathode rays chiefly by increasing the rate at which cadmium oxide and sulphur trioxide combine. With the phosphorescent sulphides of zinc, calcium, strontium and barium, the reaction which emits light is one involving the so-called impurities, for example, the salts of Cu, Bi, or Mn. Theoretically it is possible to stimulate the reactions causing fluorescence by means other than light. T. H. P.

811. Comparison of the Spectra of Fluorescent Röntgen Radiations. J. C. Chapman. (Roy. Soc., Proc. Ser. A. 88. pp. 24-87, Jan. 29, 1918.)—It is known that there are two groups of elements, series K and L, which emit characteristic X-radiations when suitably excited, and that the penetrating powers of these two sets of radiations are of the same order. Further, the empirical equation $W_K = \frac{1}{2}(W_L - 48)$ has been found to connect the atomic weights W_K and W_L of two elements which, though in different groups, emit characteristic radiations that have the same absorption coefficient in Al. In the present paper further similarities between the two groups of radiations have been found, and the identity of the two kinds of radiation established. In the first experiments the absorptions of the various radiations of both groups in Cu, Ag, and Pt was determined. In all cases the results show that if radiations from different groups suffer the same absorption in Al, then they are equally absorbed in any other element. It will be seen from the above equation that Br and Bi, though in different groups, emit radiations of equal penetrating power. The intensity of the corpuscular radiation produced in tungsten and copper and the ionisation resulting in ethyl bromide and nickel carbonyl, when equal amounts of energy of the two radiations were absorbed in these various substances, were measured by special methods and found in each case to be independent of whether the radiator was Br or Bi. These results prove that the two spectra of radiations, Group K and Group L, are identical in their nature, and this suggests that the mechanism of production is the same although the elements emitting the radiation differ widely in atomic weight. E. M.

812. Retardation of α -Particles by Metals. E. Marsden and H. Richardson. (Phil. Mag. 25. pp. 184-198, Jan., 1918.)—It has been shown that the range of α -particles from a single product depends not only on the density of the material penetrated, but also on its chemical nature. Bragg has determined the amounts of various substances necessary to cut down the range of α -particles by 1 cm. in air, and has noticed that the weights per unit area necessary for different metals are approximately proportional to the square roots of their atomic weights. Taylor [see Abstract No. 1887 (1909)] has further shown that, for layers of material of atomic weight greater than the

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average atomic weight of air, the air-equivalent decreases with decreasing velocity, or range, of the entering α -particles, while in the case of hydrogen whose atomic weight is less than that of air, the air-equivalent increases with decreasing velocity. In these experiments the ionisation method of measurement was adopted. The present apparatus consists essentially of a travelling microscope with a zinc-sulphide screen attached rigidly to the objective so as to be in focus. The source of α -particles is some radium emanation, and the metal foil whose air-equivalent is under investigation can be placed on a platform, adjusted to any required distance from the zinc sulphide screen, and the scintillations produced observed. The method adopted is to raise the microscope and attached screen until just out of range of the α -particles, (1) without, and (2) with, the foil in position. Curves are given which show that the variations of air-equivalent are quite considerable and specially noticeable for low ranges. In particular the variation of air value in the cases of Al and mica is almost entirely confined to the last 2 cm. of emergent range. It is shown that a curve can be plotted connecting mass per unit area and air-equivalent, and such curves are given for Au, Ag, and Al. A note is appended on an illumination of the screen when moved towards the source of particles just prior to the point where the scintillations begin to appear in large numbers on the screen.

A. E. G.

813. Tracks of Single α -Particles on a Photographic Plate. **W. Miehli.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1481-1447, Oct., 1912.)—Kinoshita showed [Abstract No. 922 (1910)] that when an α -particle penetrates a halide grain of a photographic plate, the whole grain becomes capable of development. Reinganum later showed that the path of an α -particle in the emulsion could be traced by the track of silver grains on development. The author has repeated and extended Reinganum's work and made quantitative measurements of the length of the tracks and the number of grains contained when α -particles of different range are used. Thus with the particular emulsion employed an α -particle of polonium produces a track of average length $28\ \mu$, and containing about 8 grains. Both the length of the track and the average number of grains were found to be linear functions of the range in air of the α -particles employed.

E. M.

814. Ionisation produced by β - and γ -Rays at High Pressures. **D. C. H. Florance.** (Phil. Mag. 25. pp. 172-188, Jan., 1918.)—The ionisation produced by γ -rays in a closed vessel is due partly to the β -rays escaping from the walls, and partly to the β -rays set up from the molecules of the gas. The author has made measurements of the ionisation due to γ -rays between two plates at various pressures up to 80 atmos., so as to completely absorb the secondary β -rays. In this way their absorption properties have been studied and compared with the results obtained with the primary β -rays of UrX deposited as a thin film on one of the plates. From the observations the apparent coefficient of absorption of the β -rays from UrX was calculated to be $0.04\ \text{cm.}^{-1}$ in air, although by a special arrangement this could be reduced to 0.007 . In the case of the γ -rays from RaC, the secondary β -rays were found to have the same absorption properties, whatever material was used for the electrodes. The "emergent" β -rays were found to have an absorption coefficient of $0.046\ \text{cm.}^{-1}$ air, and the "incident" β -rays $0.056\ \text{cm.}^{-1}$ air. Thus the "emergent" β -rays are similar in penetrating power to the β -rays of UrX. With plates of Al 1 cm. apart the ionisation in the air between them

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due to γ -rays passing normally through the plates was found to be negligible at atmospheric pressure, and approximately 25 % of the total ionisation at 80 atmos. E. M.

815. β -Rays of Radium B, C, D, E. J. Danysz. (Le Radium, 10. pp. 4-6, Jan., 1918.)—The paper deals with a redetermination of the velocities of the "bands" of β -particles in the "magnetic spectrum" [see Abstract No. 325 (1912)]. In the experimental arrangement the β -rays are made to describe a semicircle by the magnetic field before falling on a photographic plate placed parallel to the field. Values are given for 25 sets of β -particles from Ra (B + C), and it is shown that the same results are obtained whether an active Pt-wire is used or emanation contained in a thin-walled tube. The "magnetic spectrum" of Ra (D + E) shows four lines presumably due to RaD, together with a broad, diffuse band of higher velocity due to RaE. The four lines due to RaD appear to correspond to four lines due to RaB in that they have the same differences between their energies. Thus from Ra (B + C) there are 4 sets of β -particles whose energies $\times 10^{-13}/e$ are 0.866, 0.867, 0.492, and 0.522, while the energies of the RaD β -particles are $\times 10^{-13}/e$: 0.809, 0.811, 0.485, and 0.468. This seems to suggest that the differences in the energies are due to the same atomic mechanism [see Abstract No. 438 (1918)]. Photographs are given illustrating the results. E. M.

816. Penetrating Power of γ -Rays from Radium C. A. S. Russell. (Roy. Soc., Proc. Ser. A. 88. pp. 75-82, Jan. 29, 1918.)—The primary object of the experiments was to find out if there is any residual radiation from RaC after the γ -rays of ordinary penetrating power have been entirely absorbed. A γ -ray electroscope with walls of Pb 1 cm. thick was placed over an iron pot, of diam. 80 cm. and height 88 cm., which could be filled with Hg. A source of RaEm was placed near the bottom of the pot, and the absorption of the γ -rays determined by filling in different amounts of Hg. With the strong source used, 800 millicuries RaEm, no ionisation could be detected through more than 26 cm. Hg even when an ionisation vessel with air at a pressure of 80 atmos. was substituted for the electroscope. The results show that the γ -rays are absorbed over a range of thickness of 1 to 22.5 cm. strictly according to an exponential law with a value of $\mu/d = 4.88 \times 10^{-3}$. Over this range the intensity is diminished in the ratio of 860,000 to 1. This value of μ/d is very near to that found previously for lead, i.e. 4.37×10^{-3} [Abstract No. 1252 (1910)]. The author concludes that if any ionising radiation exists more penetrating than γ -rays, then its intensity is less than 2×10^{-6} of that of the initial γ -ray beam. E. M.

817. Excitation of γ -Rays by α -Rays. J. Chadwick. (Phil. Mag. 25. pp. 193-197, Jan., 1918.)—In a previous paper the author has shown that β -rays of Ra impinging on matter produce γ -rays, and in the present experiments this result has been extended to α -rays. The source employed was RaEm with its active deposit enclosed in a thin-walled glass α -ray tube. This tube was surrounded by a tube of some material of low atomic weight, say Al, just thick enough to stop all the α -rays. Then round this was placed a similar tube of a metal of high atomic weight, say gold. The ionisation produced by the γ -rays emitted by the emanation tube under these conditions was measured by a balance method in an ionisation chamber containing methyl iodide or carbon disulphide, these gases increasing the ionisation due to soft excited γ -rays relative to the hard primary γ -rays. Taking the ionisation when the

inner tube was Al as 100, the ionisation obtained with Au as the inner and Al as the outer tube was 104·8, with Ag 102·5, with Cu 101·2, and with paper 99·7. By an experiment with a magnetic field it was shown that these increased ionisations were not due to γ -rays excited by soft β -rays, but were due to γ -rays excited by the α -rays. The measurements indicated an absorption coefficient of about 8 cm.^{-1} Al for the excited γ -rays. E. M.

818. Asymmetric Emission of Secondary Rays. O. W. Richardson. (Phil. Mag. 25. pp. 144–150, Jan., 1918.)—The experiments of Bragg and others have shown that when γ - or X-rays pass through a thin plate of matter the secondary radiation is much greater on the emergent than on the incident side. Further, Stuhlmann and Kleeman have shown that when thin films of metals are traversed normally by ultra-violet light, the number of electrons emitted on the emergent is greater than on the incident side. These results lead at first sight to the view that the energy of γ -, X-, or light-radiation is not uniformly distributed but exists in a very concentrated form in limited regions, so that a single electron may be made to receive the major part of both the energy and momentum in a radiation unit. In the present paper the author considers an explanation of the above effects without making any definite hypothesis about the structure of radiation. The consideration is based on Planck's idea that the transference of energy to an electron goes on in a manner which may be treated as continuous until there is a disruption when the energy of the electron is a simple integral multiple of $h\nu$, where ν is the frequency of the radiation and $h = 6.55 \times 10^{-27} \text{ erg sec.}$ The author further supposes that the act of disruption results in the liberation of an electron to such an extent that it no longer forms part of the dynamical system to which it originally belonged. In favourable cases, especially when ν is large, the electron may be expelled from the matter and appear as secondary radiation of the β or electronic type. Thus if \bar{u} is the average component of velocity of the disrupted electrons in the direction of incidence of the radiation, v^2 the average value of the square of their velocity at the instant of disruption, c the velocity of light, the equation is deduced $\bar{u} = v^2/2c$. Thus the asymmetry of the secondary radiation should be more marked the greater the value of \bar{u}/v , and hence the greater the value of v . This is known to be the case. Further considerations are given, and the author concludes that some such theory as the foregoing must be reckoned with in explaining the effects. E. M.

819. Radium E. R. Thaller. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1611–1628, Oct., 1912.)—The experiments were carried out to decide whether RaE is a single product or consists of two successive products. A plate was exposed to RaEm and the rate of growth of the RaE from the RaD was investigated, the results indicating that RaE consists of one product only. By electrolysing a solution of Ra (D + E) acetate varying amounts of RaD were found to be deposited with the RaE, according to the current density. In every case, after allowing for the residual activity of the RaD the decay of the RaE was found to be strictly exponential, showing again that it is not complex. The half-time period was determined to be 4.85 days. E. M.

820. Heating Effect of Radium and its Emanation. E. Rutherford and H. Robinson. (Phil. Mag. 25. pp. 812–880, Feb., 1918. Akad. Wiss. Wien, Ber. 121. 2a. pp. 1491–1516, Oct., 1912.)—The apparatus employed consisted of two differential Pt-resistance thermometers similar to those employed by Rutherford and Barnes. The heating effect of the emanation in a tube with
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all its products to RaC was measured and then the emanation suddenly withdrawn. The rate of decrease of the heating effect due to the decay of the products was found to follow very accurately that of the decrease of the energy of the radiations. An estimate of the heating effect of the β - and γ -rays was obtained by surrounding a tube of emanation with cylinders of metal of various thicknesses. From the results the distribution of the heating effect between radium and its products and radiations is deduced to be:—

Substances.	Heating Effect in gm. cals. per hour corresponding to 1 gm. of Radium.			
	α -rays.	β -rays.	γ -rays.	Total.
Radium	25.1	—	—	25.1
Emanation	28.6	—	—	28.6
Radium A	80.5	—	—	80.5
Radium B }	89.4	4.7	6.4	50.5
Radium C }				
Totals	128.6	4.7	6.4	184.7

It follows that the total heating effect of 1 gm. of Ra for complete absorption of the α -, β - and γ -rays should be about 185 gm. cals. per hour on the Vienna standard. E. M.

821. Comparative Absorption of γ - and X-rays. S. J. Allen and E. J. Lorentz. (Phys. Rev. I. Ser. 2. pp. 85-49, Jan., 1918.)—The present paper is a continuation of previous experiments by Allen [Abstract No. 1088 (1912)] and deals with the softest γ -rays emitted from radium, and X-rays of various degrees of hardness. The authors succeeded in obtaining X-rays whose coefficient of absorption in Al was only four times that of the soft γ -rays. The absorption by a very large number of substances was examined. For the soft γ -rays, λ/d was found to follow the same general characteristics as previously found for the hard rays, but increasing with the atomic weight in a more rapid manner. For X-rays λ/d was also found to increase in general with the atomic weight, but with some substances, notably silver, anomalous results were obtained. These anomalous results appear to be connected with the fluorescent secondary X-radiation discovered by Barkla. No anomalous results were found for the very high weight atoms such as Pb and Pt.

E. M.

822. Emanation in Sea-water. J. Laub. (Phys. Zeitschr. 14. pp. 81-88, Jan. 15, 1918.)—The amount of emanation in sea-water was measured at 15 points in the Atlantic, 4 in the Straits of Magellan, and 81 in the Pacific along the South American coast. The mean emanation-content was 0.14 Mache unit in the Atlantic, 0.09 in the Straits, and 0.08 in the Pacific. No systematic difference in the emanation-content could be traced to temperature or to distance from coast. E. E. F.

823. Measurement of the Earth's Penetrating Radiation on Seven Balloon Ascensions. V. F. Hess. (Phys. Zeitschr. 18. pp. 1064-1091, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)

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824. *Mechanical Differential Telethermograph.* L. J. Briggs. (Washington Acad. Sci., Journ. 8. pp. 88-85, Jan. 19, 1918.)—This instrument consists essentially of two independent Bourdon spring systems, each hollow spring communicating with a copper bulb by means of a copper capillary. Each system is completely filled under pressure with a liquid having a high thermal expansion coefficient. These two systems are mounted in such a manner that the free ends of the springs move in the same plane and in opposite directions when the two systems undergo the same change in temperature. The free ends of the two Bourdon springs are connected in the plane of movement by a double link, the two members of which are approximately parallel and normal respectively to the paths traversed by the ends of the springs. The normal link is connected at its approximate centre to a second link which communicates with the pen mechanism. When the two systems undergo a simultaneous change in temperature, the free ends of the springs, in expanding or contracting, rotate about the centre of the connecting link without producing any translation of this point. No change occurs, therefore, in the position of the recording pen on the drum. When, however, a differential change in the temperature of the two systems occurs, a greater movement is produced in the free end of one Bourdon spring than in the other, and a corresponding movement of the pen-arm takes place. The instrument is thus designed to record differences in the temperature of the two systems, independent of the absolute temperature. To protect the working parts from changes of temperature, the instrument is provided with a metal cover blackened inside, and the interior is given an open construction. Applications of the apparatus to the recording of the depression in temperature of the wet-bulb thermometer, and of the changes in intensity of solar and sky radiation, are described.

A. W.

825. *Conduction of Heat along a Pipe through which Gas flows; Relation to Experiments on Specific Heats of Gases.* W. F. G. Swann. (Phil. Mag. 25. pp. 109-115, Jan., 1918. Paper read before the British Assoc. at Dundee.)—The author determined some years ago the specific heats of air and CO₂ at constant pressure. His results have been confirmed by others [see Abstract No. 504 (1912)] and agree to 1 in 1000 with the theoretical values deduced from J. Joly's determinations at constant volume. They are, however, 2.5% higher than those of Regnault. The discrepancy seems to arise through an error in Regnault's correction for the heat lost by conduction along the pipe from the heater to calorimeter and for heat lost by radiation from the calorimeter. Regnault determined the constants in his correcting equation by noting the rate of temperature-increase in the calorimeter before and after gas had passed through it. The error lies in assuming that the constant for heat conduction is the same when the gas is, or is not, flowing. This is not so because the hot gas produces a different temperature gradient in the pipe. The author makes experiments to determine the error involved, and though the exact conditions of Regnault's experiments are not repeated, the error determined is extremely near in value to the discrepancy to be explained.

H. S. R.

826. *Thermostat for Low Temperatures.* F. Henning. (Zeitschr. Instrumentenk. 88. pp. 88-88, Feb., 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—The author describes a thermostat for use at low temperatures (0° to -150°) which allows a constancy of temperature within a few hundredths of a degree. The apparatus employed cannot briefly be described, but the principle on which it depends is the cooling of a liquid (alcohol or petroleum ether) by means of liquid air. A. F.

827. *Specific Heats of Helium and some Diatomic Gases between $+20^{\circ}$ and -180° .* K. Scheel and W. Heuse. (Preuss. Akad. Wiss. Berlin, Ber. 2. pp. 44-48, 1918. Communication from the Physikal.-Techn. Reichsanstalt. Ann. d. Physik, 40. 8. pp. 478-492, March 20, 1918.)—The authors make use of the method described previously [Abstract No. 504 (1912)], except that the apparatus was so modified that a closed circuit was formed for the circulation of the gas, so that rare or poisonous gases could be investigated. The results obtained are given in the following table, where the symbols used have the ordinary signification, those marked with 0, for example k_0 , being the values calculated for the ideal gas state. The values for constant volume were calculated from the experimental numbers for constant pressure by means of expressions deduced by a combination of the ordinary thermodynamical equations with D. Berthelot's equation of condition.

Temp.	C_p in watt- secs. per gm. degree.	C_p in gm. cal. per gm. degree.	C_p	C_v	C_{p0}	C_{v0}	k	k_0
<i>Helium.</i>								
+ 18	5.278	1.26 ₀	4.993	3.008	4.993	3.008	1.660	1.660
- 180	5.22	1.24 ₅	4.934	2.949	4.934	2.949	1.673	1.673
<i>Hydrogen.</i>								
+ 16	14.26	3.403	6.860	4.875	6.860	4.875	1.407	1.407
- 76	13.23	3.157	6.865	4.379	6.364	4.379	1.453	1.453
- 181	11.08	2.644	5.330	3.338	5.320	3.335	1.597	1.595
<i>Nitrogen.</i>								
+ 20	1.044	0.249 ₂	6.983	4.989	6.969	4.984	1.400	1.398
- 181	1.071	0.255 ₆	7.162	4.879	6.718	4.733	1.468	1.419
<i>Oxygen.</i>								
+ 20	0.914	0.218 ₂	6.98 ₂	4.98 ₅	6.97 ₀	4.985	1.399	1.398
- 76	0.898	0.214	6.86	4.84	6.81	4.83	1.416	1.411
- 181	0.956	0.223	7.30	5.04	6.90	4.91	1.447	1.404
<i>Air (free from CO₂).</i>								
+ 20	1.008	0.240 ₆	6.965	4.972	6.953	4.968	1.401	1.400
- 76	1.018	0.243 ₀	7.04	5.02	6.99	5.01	1.401	1.396
- 181	1.046	0.249 ₆	7.23	4.99	6.85	4.86	1.450	1.408
<i>Carbon Monoxide.</i>								
+ 18	1.048	0.250 ₂	7.006	5.011	6.991	5.006	1.398	1.396
- 180	1.084	0.258 ₇	7.244	4.922	6.743	4.758	1.472	1.417

T. S. P.

828. *Method of obtaining Sublimates.* A. L. Fletcher. (Roy. Dublin Soc., Proc. 18. 82. pp. 460-466, Feb., 1918.)—A modification of Joly's maldometer, consisting of an electrically heated carbon rod (or Pt strip) sublimates the sample on to a cover plate of glass, silica, biscuit, etc. A few mgm. are

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usually sufficient. About 8×10^{-7} gm. of arsenious oxide or lead oxide has in this way been appreciable, and about 10^{-6} gm. of arsenic could just be identified. Various results are given showing the type of sublimes with a glass plate held near to or away from the sample, and by sublimation in H_2S , and upon an iodine sublimate. Alloys and steel may be fractionally sublimed, and small quantities of impurities have been qualitatively detected. F. R.

829. *Theory of Black Radiation.* M. Brillouin. (Comptes Rendus, 156, pp. 124-126, Jan. 18, 1918.)—From one of the last memoirs of Poincaré the hypothesis of "quanta" is an inevitable consequence of experiment if we suppose that the resonators by which we represent emissive and absorbing matter are rigorously monochromatic. This latter supposition seems to possess an excessive mathematical simplicity, which nothing will justify from an experimental standpoint. It is therefore of interest to examine the consequences of abandoning it. In the present paper the author considers a system formed of an electron revolving round a central mass, and, with the different conditions stated, shows that the total energy of the resonators in which the same period τ is established form a discontinuous sequence corresponding to the successive values of the integer n . The method of obtaining all frequencies by means of a single type of vibrating system, by variation of the energy of oscillation, is more satisfactory than the hypothesis of an infinity of monochromatic vibrators. The law of black radiation should be connected directly with the law of energy $E(r)$ as a function of the distance r of the electron, and could serve to determine this function. But, to make this clear, it would be necessary to consider the relations of the vibrating body with the ether. A. W.

830. *Atomic Theories of Radiation.* R. A. Millikan. (Science, 87, pp. 119-188, Jan. 24, 1918. Paper read before Section B of the Amer. Assoc. for Advancement of Science.)—The last fifteen years have shown the atomic and kinetic conceptions to be the most fruitful which have ever been introduced into physical science. Only in one domain have atomistic points of view failed to possess the field completely, and that the only domain in which they were securely entrenched two hundred years ago, but from which they were driven, apparently for ever, at the beginning of the last century, by the epoch-making work of Fresnel and Young. Upon this lost domain of *radiant energy* they are now making renewed attack. The present paper surveys this field of conflict and endeavours to appraise the successes and failures of each of the opposing forces from the point of view of *experimental* physics alone.

In this attack upon the domain of radiant energy, atomistic conceptions do not at present show a united front. There is not one sharply-defined atomistic theory, but there are five distinct brands of *quantum* theory of various degrees of concentration. These are alike in that they have to do with certain assumptions as to the nature of radiant energy, or as to the conditions under which such energy is absorbed or emitted by atomic or sub-atomic oscillators. The various theories are then discussed with special reference to the experimental facts which have called the five different types of assumption into being.

1. The first and least concentrated form, that of Planck, grew out of the fact that we had two radiation formulæ—(1) that of Rayleigh, and (2) that of Wien; the first of which fitted the experimental facts for long wave-lengths (for which alone it was indeed suggested), while the second fitted the experimental curve at the other end of the spectrum only, although it was

originally hoped that it would give the correct distribution of energy throughout the spectrum. Wien's general formula had been deduced from his displacement equation (an equation which rests only on thermodynamic reasoning and the proved facts of radiation pressure) with the aid of two additional assumptions, viz., (1) that the velocities of gas molecules follow the Maxwell distribution law, and (2) that the frequency of the vibrations sent out from a given molecule depends only on the temperature. Since this equation failed at long wave-lengths, and yet contained no more *particular* assumptions than those just mentioned, and since the first of these assumptions is one which we have the best of grounds for making, there was nothing to do but modify the last one. Planck modified it in such a way as to obtain an equation that would go over into Rayleigh's equation at long wave-lengths, and into Wien's at short wave-lengths. Planck's own argument is briefly somewhat thus. Boltzmann's identification of the concept of entropy in thermodynamics with the concept of probability in statistical mechanics (a step which Planck calls the "emancipation of the entropy concept from the limitations of man's experimental skill, and the elevation of the second law to a real principle") carries with it as a necessity not only the atomistic conception of matter, but also some sort of an atomistic conception of radiant energy. For the assigning of an exact numerical value to the probability of a given physical condition can be accomplished only by considering that condition as dependent on a finite number of equally likely possibilities or complexions. The greater the number of these complexions, the greater the value of the probability. Thus with two dice the probability of a four-dot throw is just three times that of a two-dot throw, because the former may occur in three equally likely ways or complexions, and the latter in only one. Now when the entropy of a physical condition is made to depend in this way on the probability of its occurrence, it may be seen at once that entropy tends toward a maximum simply because a change to a new state will not take place unless that new state has a greater probability than the old one. But, says Planck, there is no way of making the appearance of a given physical condition in a system depend in this way upon a definite, countable number of possibilities, except by conceiving the system to be made up of a definite number of concrete and definite elements, for a continuum cannot have countable elements. Hence, an atomistic structure of the system is a fundamental condition for the representation of its entropy by a probability. All systems, then, which possess an entropy must possess an atomic structure. Now experiment justifies the carrying over of the entropy concept to an enclosure filled with radiant energy, for it is only in this way that the Stefan-Boltzmann law and the Wien displacement law (both of which are found experimentally to be correct) are deduced. Hence we are forced to conclude that an atomistic structure of some sort must be applied to radiant energy. Planck then proceeds to apply it as follows. He imagines an enclosure having perfectly reflecting walls to be filled with black-body radiation. In this enclosure, and in equilibrium with the black-body radiation, are linear electromagnetic oscillators of a given frequency ν . The relation between the energy U , in each oscillator of frequency ν , and the energy per unit volume u , of black-body radiation of frequency ν , is given by the ordinary electrodynamic laws as $U = (c^2/8\pi\nu^2)u$, in which c represents the velocity of light. The idea of *atoms of energy* is next called in, and it is assumed that each oscillator contains at each instant an exact multiple of an element of energy ϵ . From a consideration then of the total number of oscillators, and the total number of energy elements in all the oscillators, we can obtain an expression, as in the

case of the dice, for the total number of complexions of the system, that is, the total number of possible distributions of the energy elements among the oscillators. This leads to an expression for the entropy of the system of the form $S = F(U/\epsilon)$. But the second law of thermodynamics as applied by Wien [Wied. Ann. 52. p. 182, 1894], had shown that $S = F(U/\nu)$. Hence we must place $\epsilon = h\nu$, that is, the energy element ϵ is proportional to the natural frequency ν of the oscillator, and the proportionality factor h is a universal constant, which Planck calls the *Wirkungsquantum*. He thus arrives at this celebrated formula for the relation between the density of black-body radiation and frequency, viz. :—

$$u_\nu = \frac{8\pi h\nu^3}{c^3} \cdot \frac{1}{e^{h\nu/ckT} - 1},$$

or, the intensity E_λ of black-body radiation of wave-length λ_1 and temperature T_1 is $E_\lambda = 2c^2h/(\lambda^5 e^{ckh/\lambda T} - 1)$.

This formula meets the requirements of passing over, at small values of λT , into Wien's equation, namely, $E_\lambda = (2c^2h/\lambda^5)e^{-ckh/\lambda T}$, and for large values of λT , into Rayleigh's equation, viz. $E_\lambda = 2ckT/\lambda^4$. Planck finds a further proof of the necessity of taking some such steps as that which he has taken in the faultlessness of Jeans's logic in showing that the Hamiltonian equations, combined with the theory of probability, lead inevitably to Rayleigh's radiation equation, which is contradicted by experiment. There is then, in his judgment, nothing whatever to do except to deny the general validity of the Hamiltonian differential equations, and this is precisely what he has done. Furthermore, the fact that his own equation goes over into Rayleigh's equation when h is made infinitely small seems to him to show decisively that certain elementary radiation processes which in Jeans's theory are assumed to be continuous are in fact discontinuous.

During 1912 Planck modified his theory to meet an objection put forward by Poincaré as to the profound revolution of physics which would be involved by the assumption that physical phenomena do not obey laws expressible by differential equations. Planck's original theory implied that both absorption and emission of energy by the oscillator must take place in units—that is, discontinuously. Planck's modified idea is that emission alone takes place discontinuously, while the absorption process is continuous. At the instant at which a quantity of energy $h\nu$ has been absorbed an oscillator has a chance of emitting the whole of its unit—a chance which, however, it does not necessarily take. If it in this way misses fire it has no other chance until the absorbed energy has arisen to $2h\nu$, when it has again the chance of throwing out its two whole units, but nothing less. If again it misses fire its energy rises to $3h\nu$, $4h\nu$, etc. The ratio between the chance of not emitting when crossing a multiple of $h\nu$, and the chance of emitting, is assumed to be proportional to the intensity of the radiation which is falling upon the oscillator.

This, then, is at present the most fundamental and the least revolutionary form of quantum theory, since it modifies classical theory only in the assumption of discontinuities in *time*, but not in *space*, in the emission (not in the absorption) of radiant energy.

2. The second of these theories is somewhat more radical than that just noticed; it is, in fact, merely that originally proposed by Planck. Despite the fact that Planck has renounced this point of view, the theory refuses to die. Nernst and most of the investigators who are working in specific-heat relations still adhere to it. What is the experimental situation which seems

to demand it? It is that brought about by the recent development of methods of studying specific heats at high and low temperatures, especially the liquefactions of hydrogen and helium.

8. We now come to forms of atomistic theory which make radical assumptions regarding the distribution of radiant energy in *space* rather than in *time*. The least radical of these, because the least general, is that of which Bragg is the most active exponent. It is frankly corpuscular. It was developed, however, with a view of explaining the properties of one type of radiation only, namely, X-rays and γ -rays, and at a time when there was some justification for regarding these as isolated phenomena.

4. A general hypothesis was made by J. J. Thomson in his Silliman lectures in 1908. It was, historically, the first form of the modern atomistic theories of radiation as regards space relations, although it is here treated in the fourth place, because it is considered to stand fourth in the violence of the assumptions involved. Like Bragg's theory, it postulates radiant energy which is emitted by the source in bundles or quanta, though no necessary multiple relationship was at first assumed between the different elements emitted by the same source. It goes farther than Bragg's theory in endeavouring to reconcile this quantum notion with the wave theory by assuming a fibrous structure in the ether and picturing all electromagnetic energy as travelling along Faraday lines of force conceived as actual strings extending through all space. To the support of such an hypothesis are brought all the arguments urged for Bragg's theory, while the arguments which the present author urges against Bragg's theory are removed.

5. The most concentrated form of quantum hypothesis is that proposed by Einstein in 1905 [Abstract No. 1562 (1905)]. It is simply the J. J. Thomson theory of the discontinuous distribution of radiant energy in space, assumed still to be electromagnetic, and hence to have a velocity independent of that of the source, with the addition of Planck's original assumption that a given source emits and absorbs energy in units which are multiples of $h\nu$.

Reviewing the experimental data, the author recognises two main results which stand out conspicuously. (1) Neither atoms nor electrons appear to be able to absorb any energy until it comes to them in a certain degree of intensity, and this degree varies with different substances. (2) In all types of experiments in which the absorption of energy results in the emission of electrons there is apparently a complete, or nearly complete, inter-convertibility of energy between an electron and a so-called ether ray, whether it be an X-ray or a light ray.

One group of the theorists focus attention on one of the above results, another on the other. The fifth and last of the quantum theories is designed to cover both groups of facts which are obviously most completely interpreted in terms of such a theory, however radical it may be. Why not adopt it? Simply because no one has thus far seen any way of *reconciling* such a theory with the facts of *diffraction* and *interference* so completely in harmony in every particular with the old theory of ether waves. The author leaves the point at issue undecided.

E. H. B.

831. *Method of obtaining p-T-Lines for constructing Diagrams of State.* G. Tammann. (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 7. pp. 790-802, 1912.)—For temperature-regions in which it is difficult to maintain a constant temperature (above 100° and below 0°), the measurement of the equilibrium pressures at constant temperature may be replaced by a method depending on the simultaneous observation of pressure and tempera-

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ture during the heating of the substance under investigation. As regards the external conditions, two principal cases are to be distinguished : (1) the substance is kept at constant volume ; (2) this is not the case, so that the volume alters with p and T . From the p - T -curves the equilibrium (melting and transformation) curves may be readily constructed, and, with the aid of these curves and of the compressibility, the changes of volume, Δv , during change of state under constant temperature or constant pressure are easily derivable. Further, from Δv and the direction of the equilibrium curve (dT/dp), the heats of fusion for different pressures can be calculated. This procedure may be applied, not only to individual substances, but also to systems of two or more components. The above relations are worked out mathematically.

T. H. P.

832. *Adiabatic Increase of Entropy.* P. Duhem. (Comptes Rendus, 156. pp. 284-286, Jan. 27, 1913.)—The author critically examines the general proposition that "if a system is enclosed in an envelope impermeable to heat, every modification accompanied by viscous work entails an increase of entropy." Although nobody has called the proposition into question, the author treats the subject rigidly from the standpoint of established laws.

H. H. Ho.

833. *On the Elements of Energy.* J. Duclaux. (Comptes Rendus, 156. pp. 142-144, Jan. 18, 1913.)—According to the rule of Pictet and Trouton, the quotient ML/T is approximately a constant for different liquids ; likewise the quotient Q/T , where Q is the heat of dissociation of a substance, is also approximately the same for different substances. We are therefore led to the conclusion that when a union between atoms or between molecules is broken in a reversible manner at the absolute temperature T , a quantity kT of heat is absorbed, k being a constant (equal to 21) independent of the nature of the union. The author calculates the heat (or energy) required to rupture a single bond, and finds the value to be $\epsilon = 9.5 \times 10^{-16} T$, measured in ergs. This "element of energy" is the smallest quantity of energy concerned in a chemical transformation or in a change of state at the temperature T . When we compare this element of energy with that of Planck, which is the smallest quantity of energy which can take part in a radiation of the wave-length λ , a very close agreement is found between the two numbers. The author points out that if the values are really identical, the quanta hypothesis of Planck becomes simply a new form of the Pictet-Trouton rule.

A. F.

834. *Statistical Theory of Radiation.* K. F. Herzfeld. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1449-1468, Oct., 1912.)—Mathematical treatment.

E. H. B.

835. *Canonical Equation of Condition of Solids and the Quanta Theory.* K. Eisenmann. (Ann. d. Physik, 89. 6. pp. 1165-1174, Dec. 23, 1912.)—Shows that on the basis of the theory of quanta a complete derivation of the energy and of the equation of condition of a solid body can be given after introducing a distribution function.

E. E. F.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

836. *Electromotive Force of Accelerated Conductors.* R. C. Tolman. (Science, 87. pp. 192-198, Jan. 31, 1918.)—The possibility that electromotive forces might be produced by the mechanical acceleration of electric conductors was first thoroughly considered by Maxwell (Treatise on Magnetism and Electricity, vol. ii. 211, etc., 3rd Edition), and the actual presence of such electromotive forces in electrolytic conductors was shown by Colley in 1882 (Wied. Ann. 17. p. 55, 1882). The author's experiments have so far shown that the effect in metals, if existent, is smaller than in electrolytes. The apparatus is now being improved with the hope of detecting the effect in metals. E. H. B.

837. *Charge of Photoelectric Electrons.* E. Alberti. (Ann. d. Physik, 89. 6. pp. 1183-1164, Dec. 28, 1912. Extract from Dissertation, Berlin.)—The specific charge of photoelectric electrons has been roughly determined by Lenard [Abstract No. 1845 (1900)] and Thomson [Abstract No. 1294 (1900)]. The rays composed of these electrons are very homogeneous, of velocity negligible in comparison with that due to 10,000 volts, and obtainable in the highest vacuum. On the other hand, the electron current is small and the phosphorescence feeble. The author used a mercury-vapour lamp, quartz lenses, and a copper kathode. The rays, accelerated by an electric field, and deflected by a magnetic field, cast the shadows of copper wires on to a screen of Sidot blende. The mean value of 129 observations for the specific charge e/m is 1.756×10^7 in good agreement with previous values. E. E. F.

838. *Some Electron Orbits.* C. G. Darwin. (Phil. Mag. 25. pp. 201-210, Feb., 1913.)—In order to find the characteristics of such processes as the absorption by matter of β - and kathode-rays, it is necessary to have a knowledge of the orbits of the electrons as they pass the various charged bodies in matter. According to Rutherford's theory [see Abstract No. 1847 (1911)], which is strongly supported by experiments, an atom is composed of electrons and a nucleus of positive electricity of charge such as to neutralise them. The nucleus is seated at the centre of the atom, bears nearly the whole mass, and has its charge concentrated inside a very small region. The present paper is concerned with the orbit of a β -particle as it passes such a nucleus. On account of its high velocity, a β -particle has apparent mass sensibly greater than that of a slow-moving electron, and during the path the attractive force of the nucleus still further increases it. The variability of mass entirely alters the character of the orbit, with the result that in certain cases it becomes a spiral, going right in to the centre. Numerical calculation shows that these cases should be of fairly frequent occurrence. The physical reason for this may be seen in the following way. On account of the increased mass the particle, when near the nucleus, will be moving slower than it would be if its mass were constant. This gives the attractive force more time in which to exert its effect, and analysis shows that in some cases the particle is unable to escape. The problem is then worked out mathematically on the basis of Lorentz's deformable electron. E. H. B.

839. Speed of Electrons in Photoelectric Effect, as Function of the Light Wave-lengths. **D. W. Cornelius.** (Phys. Rev. 1. Ser. 2. pp. 16-84, Jan., 1918.)—The chief results of this experimental research are as follows:—(1) A small amount of residual gas in the photoelectric cell influences its behaviour. (2) The surface conditions of the alkali metal has a very large influence upon the photoelectric effect; which may be constant or increase or decrease with time. (3) It usually requires time for a cell to reach a steady state of sensibility. (4) The attempts to measure the speeds of the electrons by means of the magnetic deflection have been unsuccessful. (5) The results obtained indicate that the equilibrium potential depends to some extent on the temperature of the metal if above 0° C. (6) The relation of the speed of the electrons and the frequency of the incident light is the same for: a pure potassium, potassium "fixed" with hydrogen, caesium, and caesium "fixed" with hydrogen. And the relation between the equilibrium potential and the frequency of the incident light is the more constant the nearer the metal approaches the permanent state of sensitiveness. (7) The theoretical and calculated values of the initial speed of the electrons are both of the order of 10^7 cm. per sec. (8) The theoretical value of the time needed for the expulsion of an electron due to the resonance effect of the incident light is of the order of 10^{-7} second. (9) The equilibrium potential of the electrons in the photoelectric effect varies directly as the square of the frequency of the incident light. Planck's law, according to which the units of the electromagnetic energy are proportional to the frequency is not confirmed. (10) While the theory of resonance shows that a beam of light may supply a sufficient amount of energy for the electron to escape, it cannot satisfactorily account for the essential fact that the speed of the electrons escaping from the metal is proportional to the frequency. [See Abstract No. 1201 (1911).]

E. H. B.

840. Brownian Motions in Gases at Low Pressures. **R. A. Millikan.** (Le Radium, 10. pp. 15-16, Jan., 1918. Phys. Rev. 1. Ser. 2. pp. 218-221, March, 1918.)—The mean Brownian displacement is shown to be expressed by—

$$D = \sqrt{\frac{4}{\pi} \frac{RT(v_1 + v_2)_1 t}{E(Ne)}}$$

where R is the gas constant, T the absolute temperature, E the electric field, N the number of molecules in a gm.-mol., e the electronic charge, $(v_1 + v_2)_1$ the greatest common divisor of the series of values estimated from the sum of the velocities $(v_1 + v_2)$ when the oil droplet modifies its charge by the capture of ions. From this and the experimental data it is calculated that $e = 4.772 \times 10^{-9}$.

E. H. B.

841. Variation of Electronic Mass. **J. Kunz.** (Archives des Sciences, 85. pp. 28-89, Jan. 15, 1918.)—A mathematical determination of the variation of the mass of an electron as a function of its velocity.

E. H. B.

842. Electrification by Spraying Liquids. II. **C. Christiansen.** (Ann. d. Physik, 40. 2. pp. 283-248, Feb. 4, 1918.)—A continuation of a previous article [see Abstract No. 468 (1918)]. The present paper deals with experiments chiefly on organic compounds, the results occupying over thirty tables.

E. H. B.

843. Stokes' Law of Falling Drops and Electronic Charge. **A. Schidlöf and [Miss] J. Murzynowska.** (Comptes Rendus, 156. pp. 804-807, VOL. XVI.—A.—1918.

Jan. 27, 1918.)—An application of Cunningham's correction to Stokes' law is used in dealing with new observations of falling drops. The mean value deduced is $\epsilon_0 = 4.788 \times 10^{-10}$ in good agreement with the latest results of Millikan. [See Abstract No. 477 (1918).] E. H. B.

844. *Electric Dust-figures on Electrophorus Plate.* G. Quincke. (Deutsch. Phys. Gesell., Verh. 15. 4. pp. 96–101, Feb. 28, 1918.)—The author places a hollow metal hemisphere on the plate of an electrophorus, and near it he places a prism or biprism of conducting or insulating material with the edge vertical. He charges the hemisphere by a spark from a Leyden jar; then removes it without discharging it and sprinkles on the plate a mixture of sulphur powder and red lead. He describes the figures thus obtained and how the lines passing from the charged body behave on the further side of the prism or biprism. There is a considerable difference in the figures according as the body is charged positively or negatively. The author explains the formation of the various figures by a reference to his theory of the "foam-structure" of matter [see, for instance, Abstract No. 1523 (1906)]. T. P. B.

845. *Rectilinear Motion of Born's Rigid Electrons.* W. Behrens and E. Hecke. (Gesell. Wiss. Göttingen, Nachr., Math.-phys.-Klasse, 7. pp. 849–860, 1912.)—Mathematical treatment showing that under certain limitations the motion of an electron can be determined from its initial position and velocity. E. H. B.

DISCHARGE AND OSCILLATIONS.

846. *The Acetylene-Electric Flame.* C. F. Lorenz. (Electrical World, 61. pp. 511–515, March 8, 1918.)—When a powerful electric field is applied at right angles to a gas flame, the flame is deflected towards the kathode. There is no deflection until the anode is inside the invisible vapour mantle surrounding the flame, and the deflection is accompanied by a small current through the flame. The deflection is due to the greater potential drop at the kathode, brought about by the greater mobility of the negative carriers. If a heavy current is passed, the action at the kathode is confined to one spot, which is heated sufficiently to emit ions copiously, and then the deflection ceases. If an arc discharge is passed at right angles to a flame carrying a large proportion of free carbon there is a great increase in the luminosity of the flame. Acetylene is found to be a convenient illuminant, and curves are given showing the increased c.p. and the watts consumed. Direct current is more efficient than alternating, but the watt consumption for the increased c.p. is high. It is suggested that this type of flame is an efficient source of ultra-violet light [see Abstract No. 235 (1907)]. T. P. B.

847. *Mobility of the Positive Ion at Low Pressures.* G. W. Todd. (Phil. Mag. 25. pp. 168–171, Jan., 1918.)—In a previous paper [Abstract No. 868 (1912)] the author has shown that the mobility of the positive ion in gases at low pressures departs from the inverse pressure law, but at pressures much lower than is the case with negative ions. In the present paper further measurements have been made using the alternating field method as before. Owing to the fact that the dimensions of the measuring apparatus became of the order of about fifty free paths of the gas molecules at the lowest pressures in the previous experiments, it was impossible to draw definite conclusions
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as to the mass of the carrier from measurements of the mobility; consequently an apparatus was used on which the ions were made to oscillate over a much larger distance, *i.e.* 20 cm. By a special arrangement it was ensured that the field over this large distance was uniform at any instant. The positive ions were supplied by heated aluminium phosphate and the measurement of the mobility made by plotting the current in the electroscope for various values of the alternating potential. The results show the deviations of the mobility from the inverse pressure law to be much less marked than in the case when a smaller chamber was used. Further, the apparent mobility at a given pressure was found to increase largely with increasing frequency of the electric field. These results point to the conclusion that the positive ion, like the negative ion, has to travel a very considerable number of molecular free paths before an equilibrium state of ionisation exists. If the distance over which the mobility is measured is small and the source near one boundary of this distance, the proportion of ions reaching the other boundary as aggregates of gas molecules will be smaller than if the distance had been sufficiently large for equilibrium to have been reached. The experimental results lend some support to Kleeman's idea of a continually changing ionic aggregate. E. M.

848. Recombination of Ions produced by Röntgen Rays. S. J. Plimpton. (Phil. Mag. 25, pp. 65-81, Jan., 1918. Amer. Journ. Sci. 85, pp. 39-53, Jan., 1918.)—The method employed in the experiments consists essentially in ionising the gas between two parallel-plate electrodes as uniformly as possible by means of a single flash from a Röntgen-ray bulb, allowing the ions thus produced to recombine in the absence of any external field for small intervals of time regulated mechanically, and, by the sudden application of a strong electric field, driving over to the electrodes those ions which remain in the gas. The arrangement was such that the intensity of the flash of X-rays could be reproduced accurately, and in this way a series of relative values of n , the number of ions present at time t after the flash, which was of about 0.008 sec. duration, were obtained. The values of α , the coefficient of recombination [$du/dt = \alpha n^2$] were deduced from the curve connecting $1/n$ and t , since $\alpha = d(1/n)/dt$. For all the gases examined: air, CO₂, SO₂, CH₃I, (C₂H₅)₂, C₂H₅Cl, C₂H₅Br, (C₂H₅)₂O, for short intervals of time up to about 0.8 sec. a marked curvature was found in the curves connecting $1/n$ and t , indicating that α is relatively large for the initial stages of recombination, but diminishes later, becoming practically constant. The author explains this effect on the assumption of a non-uniform distribution of the ionisation produced by Röntgen rays, the final values of α corresponding to an effectively uniform distribution. The experiments also show that the value of α decreases considerably with decreasing pressure of the gases examined. E. M.

849. Ionisation by Röntgen Rays. F. Lebeau. (Journ. de Physique, 8, Ser. 5, pp. 111-128, Feb., 1918.)—E. Meyer has shown [see Abstract No. 1196 (1912)] that the current produced in an ionisation chamber by a bundle of γ -rays emitted from Ra varies irregularly, about a certain mean value, in course of time. In the present experiments it is attempted to obtain with Röntgen rays fluctuations proceeding from the variation in the number of molecules ionised by a bundle of constant intensity. It is possible to obtain induction coil discharges of a uniform character. The bundle of Röntgen rays produced by the passage of a single one of such discharges always sets free in a given ionisation chamber the same quantity of electricity. By diminishing

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sufficiently the number of ions produced it might be possible to put in evidence fluctuations in this number of ions about a mean value. In order to be able to show such small deviations from the mean value, it becomes necessary to multiply the initial number of ions by ionisation due to collision, in some such manner as was employed by Rutherford for α -rays. The experimental arrangement with details of the observations is given in the following cases: When the direction of the rays is parallel to the plane of the electrodes, (a) without striking, (b) with striking; and when the rays are normal to the electrode. The fluctuations in the ionisation due to secondary cathodic rays produced by Röntgen rays striking the electrodes laterally or normally are shown to exist. The mean fluctuation increases when the multiplication by ionisation due to collision increases. In a particular case very large regular discontinuities have been obtained. An augmentation of the current takes place under the influence of successive rapidly repeated discharges. This augmentation, at least in the region of the critical pressure, seems to proceed from an action exercised by the Röntgen rays upon the gaseous molecules, which are thus rendered more susceptible to ionisation by collision. When the direction of the rays is normal to the electrodes, there occur from time to time extraordinarily large variations among discharges giving regular deviations. The process of ionisation for such strong discharges appears to be localised at the surface of the brass plate acting as insulated electrode.

A. E. G.

850. Photoelectric Behaviour of Iron in Active and Passive State. H. S. Allen. (Roy. Soc., Proc. Ser. A. 88. pp. 70-74, Jan. 29, 1918.)—It is well known that ordinary iron, which is acted on energetically by dilute HNO_3 , can be made to assume a passive condition by immersion in strong HNO_3 or by other powerful oxidising agents. The author has compared the photoelectric activity of iron in the active state with that of the same sample in the passive state, dry iron plates being used in each case. The photoelectric activity measured was that due to the light from a Hg lamp. The experiments prove that iron which is chemically active is active in the photoelectric sense, while iron which is passive shows much smaller photoelectric activity—in some cases none that can be detected. The author holds that this result is in good agreement with the theory which attributes passivity to the condition of the gaseous layer at the surface of the metal.

E. M.

851. Photography of Particles ejected from Atoms. C. T. R. Wilson. (Engineering, 95. pp. 862-864, March 14, 1918. Paper read before the Royal Inst., April 11, 1918.)—By aid of Röntgen rays electrons may be ejected from ordinary atoms. The methods used in the study of electrons were usually indirect. But even electrons, when ejected, left trails behind them, and these the author has been able to photograph. Each electron ejected traversed a large number of gas atoms. But each such atom, on modern theories, is a miniature solar system, the planets being represented by electrons, which were held together by electrical instead of gravitational forces. When a disturbance of sufficient violence was set up, an electron might escape from one system and might become attached to another system. Now molecules of gases or vapours would more readily attach themselves to charged ions than to uncharged atoms, and every ion could be made a centre of condensation in supersaturated water-vapour. The author by aid of his *cloud-chamber* can now catch the ions in the positions occupied

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by them when just set free. The trail of a particle, invisible in itself, is thus marked by a crowded line of cloud, and individual ions could be distinguished under certain conditions. Nine photographs taken in this way are included in the paper as well as three diagrams explanatory of the experimental methods adopted.

E. H. B.

852. Positive Ionisation produced by Platinum and Certain Salts when Heated. F. HORTON. (Roy. Soc., Proc. Ser. A. 88. pp. 117-146, Feb. 24, 1918.)—Spectroscopic investigation of the nature of the carriers of positive electricity when an electric current is sent from a glowing Pt strip covered with aluminium phosphate to a surrounding Pt electrode in a highly evacuated vessel, shows that CO gas is evolved, and is probably the carrier of positive electricity. Hydrogen was also detected, and it seems probable that atoms of hydrogen also take part in carrying the current, for Garrett [see Abstract No. 117 (1911)] has found that about 10% of the positive ions present when aluminium phosphate is heated on a Pt strip in a vacuum have a mass corresponding to that of the hydrogen atom. Richardson, however, has come to the conclusion that the positive ions emitted by heated salts are charged atoms of the metallic constituent of the salt under test, and that in the case of the incandescent metals the carriers of positive electricity are charged atoms of Na or K which are present as impurities in the form of salts. It is in order to obtain further evidence on this matter that the experiments described in the present paper are undertaken. The general method is as follows:—The positive leak from a strip of Pt-foil is first investigated: observations being made of its rate of decay with time, of its variation with the p.d. used, and with the gas pressure in the apparatus. The strip is then covered with the salt to be tested and the observations repeated. Four samples of aluminium phosphate, two of sodium ortho-phosphate, and one of sodium pyro-phosphate are thus investigated, comparisons being made, in particular, at 1080° C. and 1190° C. In the experiments with Pt it is found that after leaving the strip cold overnight, a much larger current is obtained when first testing on the following morning. This abnormal current only lasts for a short time: in a few minutes the leak decreases to a steady value, usually somewhat smaller than on the previous evening. This decrease is accompanied by a slight increase in the electrical resistance of the strip, which suggests that some volatile product is subliming from its surface. From the curve given it can be seen that up to 820 volts the current is never completely saturated, but that after about 120 volts it increases approximately proportionally to the voltage. It is thought that the difficulty of saturating the current is due to the presence of slowly moving ions. The experiments described show that there are considerable variations both in the magnitude and in the permanence of the positive emission from different substances. In the case of Pt and of pure aluminium phosphate the initial emission decreases rapidly with the time, and in the course of a few hours' heating at a high temperature becomes extremely small. With sodium phosphate, on the other hand, the emission at first increases, and then decreases much more slowly than with the other substances tested: so that, after many hours' heating, a considerable current can be obtained. Impure aluminium phosphate falls between these cases. This is accounted for by the fact that impure phosphate contains sodium, which gradually disappears from the anode in the course of heating. The opinion is put forward that the ionisation from Pt (and from metals generally) is largely due to the emission of absorbed gases on heating, but that in the case of sodium phosphate a con-

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siderable part of the emission consists of positively-charged sodium atoms, the final value of the current in a good vacuum, after long-continued heating, being almost entirely due to this cause, although at first there is a large current due to the evolution of ionised gas, which probably comes partly from the salt and partly from the Pt on which it is heated. It seems probable that the anode rays of Gehrcke and Reichenheim are essentially the same as the emission, in a good vacuum, from a positively-charged salt which has been heated until the steady state is reached. There can be little doubt that the large emission on first heating a Pt anode is due to escaping gas which comes from inside the metal in an ionised condition. It is difficult to see any explanation on the supposition that the ions are atoms of sodium or potassium. If the gas actually carries the current, we see at once the cause of the rapid fall of emission from a new wire, for when the wire is heated the gas pressure inside it is increased and the gas diffuses out until there is equilibrium between the internal and external conditions. When after long-continued heating equilibrium is attained, there are as many gas atoms or molecules entering the wire, in a given time, as there are emitted by the wire. The latter are ionised; a certain proportion of them (probably a very small proportion) are positively charged, and it is the charges carried by these which constitute the small "steady" current which is given by a wire that has been heated for a long time. It seems probable that some of the ionisation which is produced when certain salts are heated has its origin in chemical actions between vapours produced by these salts and the platinum on which they are heated. This view has already been put forward by Richardson to explain certain ionisation effects which he obtained when various salts were heated to a high temperature in a platinum tube.

A. E. G.

853. Some Characteristic Curves for Gases at Low Pressures. R. F. Earhart. (Phys. Rev. 1. Ser. 2. pp. 85-95, Feb., 1918.)—The kathode used consists of a plate made up of ten concentric brass rings separated by an insulating material. Its face is in a horizontal plane and has a total conducting area of 85 sq. cm. The anode consists of a hemisphere of Pt, 2 mm. diam., mounted on a vertical brass rod which is covered with a thin glass envelope leaving only the hemisphere exposed. The anode is capable of adjustment vertically, but is always symmetrical with reference to the kathode. The discharge apparatus is contained in a bell-jar of about 10 litres' capacity. Characteristic curves showing the relations between current and potential under stated conditions of pressure and distance are obtained for air, hydrogen, and CO₂ in the region of the critical potentials. It is also found that the strength of a current through a gas at low pressures is determined in part by the size of the kathode. Empirical formulæ for the discharge from a positively-electrified point cannot be extrapolated from high pressure and potential regions to low pressure conditions. Introducing a constriction into the path of a discharge has the effect of increasing the apparent resistance of a circuit, this increase varying directly with the length of the constricted portion.

A. E. G.

854. Motion of Luminous Centres in Hydrogen Tubes. A. Perot. (Comptes Rendus, 156. pp. 182-185, Jan. 18, 1918.)—The tubes used were of H-form, with Al electrodes, and were immersed, for cooling purposes, in a vessel of water. A dynamo furnished a current of 0.2 amp. at 10,000 volts; this could be regulated. An étalon 10 mm. thick was used, and the light from the tube passed through a red screen before reaching the étalon. If the light issuing

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from the end of the horizontal part of the H-tube is used, then the variation of wave-length produced on reversing the current is connected with the velocity v of the centres of emission by the relation $\partial\lambda/\lambda = v/V$, where V is the velocity of light. If the light from the horizontal tube is observed at a direction inclined to its axis and the current is reversed, the velocity measured (v') is connected with the velocity v by the relation $v = v'/\cos \alpha$, where α is the angle the direction of the tube makes with the normal to the étalon. The two methods of operation have given the same numerical results. Three factors influence the velocity of the emission centres: the pressure, the intensity of the current, and the diam. of the tube. For a given tube at constant pressure the velocity increases with the intensity of the current. With a normal tube the following values were found, corresponding respectively to currents of 11, 16.25, 22 milliamps.: 149, 219, and 266 m. per sec. With a special tube whose capillary was 1 mm. diam., velocities of 815 and 1190 m. per sec. were found for currents of 100 and 144 milliamps. respectively. For the same current and constant pressure the velocity is greater the narrower the tube; and the ratio of the velocity to the square root of the current density does not vary much. For a given tube and a given intensity of current the velocity increases when the pressure is diminished, but in a certain pressure interval a tube can give different velocities according as the pressure is increased or decreased to the value considered. The greatest velocity observed was 1740 m. per sec. in a tube of 1 mm. diam., the current being 0.152 amp., giving a current density of about 0.2 amp. per mm.². This velocity is of the order of that found by the author for solar hydrogen, 8800 m. per sec. A. W.

855. Velocity of Emission Centres in Hydrogen Tubes. A. Perot. (Comptes Rendus, 156. pp. 810-812, Jan. 27, 1918.)—In a previous paper [see preceding Abstract] the author has shown that in a hydrogen tube the luminous centres move from the cathode towards the anode with a velocity which, measured by the Doppler-Fizeau effect on the red line $\lambda = 6568$, was found to vary with the pressure, the intensity of the current, and the diameter of the capillary. The present paper extends the results previously given. It was found that between certain pressure-limits the tube could exhibit two modes, the one with striations, the other without, and that in the first of these the velocities observed were greater than in the second. Experiments were made with a view to determining the velocity of the centres in different regions of a capillary showing striations. Using the method previously described, where the tube is inclined to the normal to the étalon, and projecting on the étalon an image of the tube, it was found that although the bright and dark regions could not be sharply isolated, the velocity of the centres is much greater in the bright parts than in the dark parts of the tube. Thus, with a pressure of 2.2 mm., current 0.1 amp., capillary 4.5 mm. diam., the velocity in the bright parts was 942 and in the dark parts 887 m. per sec. For a pressure of 8.8 mm. and the same current the maximum velocity was 625, the minimum 379 m. per sec. Wilson showed that the electric intensity is greater in the bright than in the dark regions of the striations; this fact is certainly connected with the results now obtained. Measurements were next made with the line $\lambda = 4861.3$. With the same tube and the same conditions, measurements with the C and F lines gave different numbers, whose ratio appeared to be constant and equal to 1.6, the velocity measured with the line of shorter wave-length being the greater. This result is explained by the different damping of the two radiations. The ratio deduced theoretically is 1.8. A. W.

856. Dielectric Cohesion. E. Bouty. (Comptes Rendus, 156. pp. 25-28, Jan. 6, 1918.)—The apparent dielectric cohesion of a gas in a small bulb [see Abstract No. 664 (1918)] is $B = 1.165b + 6$, where b is the normal dielectric cohesion as measured in large bulbs. For large values of b this makes B sensibly proportional to b ; and in small bulbs the exterior field should bear to the field within the bulb the ratio 1.178 : 1, which is practically the same as the coefficient 1.165 above. The discharge in the bulb occasionally lags behind the external field; more markedly in small bulbs. This seems to depend on a condition of the gas (*e.g.* the attainment of ionising velocity by the ions) adversely affected when the volume is small. The phenomena can be explained by considering the work done ($=y$ per unit of electric quantity) in the initial stage of disruptive discharge as divided into two parts: (1) that done along the course of the gas itself, proportional to the field and to the thickness; and (2) that done at the electrodes or the wall, provided that this increase linearly with the pressure. This seems to be the case in neon. Experiment is necessary to see whether the coefficient 1.165 above is the same for all gases. A. D.

857. Current Distribution at the Kathode of Discharge Tubes. A. Wehnelt. (Deutsch. Phys. Gesell., Verh. 15. 2. pp. 47-52, Jan. 80, 1918.)—Goldstein has shown that at low pressure there are, in addition to the visible kathode-ray bundle, rays which issue from the whole cathodic surface. The author has made these rays visible by means of a screen, and has suggested that they are produced by the ultra-violet light given out during the discharge [see Abstract No. 1867 (1912)]. Now that a more sensitive galvanometer is used it is proved that this influence of the ultra-violet light is insignificant. Detailed descriptions of the apparatus and measurements taken are given. It is concluded that the kathode-ray bundle does not carry the whole current, but there are also positive ions which move up towards the kathode and ionise the gas at its surface. The ultra-violet light or soft Röntgen rays due to the discharge have also a slight influence by liberating electrons in the metal. A. E. G.

858. Disintegration of Metals at High Temperatures. Condensation Nuclei from Hot Wires. J. H. T. Roberts. (Phil. Mag. 25. pp. 270-296, Feb., 1918.)—In a preliminary account of experiments upon the disintegration of metals, more particularly the platinum metals, the theory was put forward that the disintegration of the platinum metals was due to direct oxidation [see Abstract No. 1767 (1912)]. That platinum does not, under any circumstances, combine directly with oxygen has caused a diffidence in suggesting that the influence of oxygen is other than catalytic, and there are, moreover, certain experimental facts which at first sight appear to militate against the theory that the disintegration is due to direct oxidation. In the present experiments, in which Wilson's condensation method is adopted, the wire is not placed in the expansion chamber, but in a separate chamber so that no water-drops can fall upon it. The wire is heated by a current developed from an alternator and transformer set. On their way to the expansion chamber the nuclei pass through an annular space, 2 mm. wide, between two brass tubes insulated from one another, the outer one earthed, the inner at -280 volts. There are two well-marked conditions governing the production of nuclei: (1) The recent history of the wire previous to the experiments. (2) The length of time since the commencement of experiments. There are two sets of nuclei: the first, got rid of after continuous

experimenting, depend upon the presence of hydrogen and other gases in the wire ; the second depend upon the presence of oxygen round the wire : below a certain temperature the second set are never obtained. The metals experimented upon are platinum, palladium, rhodium, iridium, and ruthenium. It is found that platinum begins to disintegrate at as low a temperature as $500^{\circ}\text{C}.$, but no loss of weight could be detected even after days of heating. The disintegration begins to come within the range of the balance between $1000^{\circ}\text{C}.$ and $1100^{\circ}\text{C}.$ The second set of nuclei even at $500^{\circ}\text{C}.$ are very persistent, and do not change in size or character, being produced in pure oxygen, no matter how long the heating has been continued ; they are not produced in the absence of oxygen. This shows that they are not likely to be either particles of the metal brought off by the escaping gas or traces of compounds of different gases. The rate of loss of weight of the Pt-wire is roughly proportional to the oxygen pressure, which points to the formation of an endothermic oxide. Experiments in a constant-volume gas chamber, in which the loss of Pt to loss of oxygen is determined, give results which approximate in the case of air to $2\text{Pt} : \text{O}$ and in the case of oxygen to $\text{Pt} : 2\text{O}$. It does not seem probable that this large amount of oxygen is simply adsorbed : it must be combined chemically, at any rate for the most part. During the cooling of the oxide after its formation at the hot wire some decomposition takes place, and the amount of the decomposition will be greater the lower the oxygen pressure. If we assume that the quantity of oxygen adsorbed by the deposit is small, the composition of the oxide in the experiments in oxygen must be either PtO , or some higher oxide. If the oxide is also present in the deposit in air, there must be a considerable amount of Pt mixed with it, this Pt being the result of dissociation of the oxide during cooling. The formation of an endothermic volatile and dissociable oxide not only explains all the observed facts, but will also explain certain facts in the discharge of negative and positive electricity from hot Pt-wires at low pressures.

A. E. G.

859. Duration of Luminosity of Electric Discharge in Gases and Vapours. R. J. Strutt. (Roy. Soc., Proc. Ser. A. 88, pp. 110–117, Feb. 24, 1918.)—The object of the paper is to systematise and extend the somewhat scattered observations bearing on this subject. A new method of observing the “streamers” is described which in principle is as follows :—The electrodes are wires of the metal under observation. They are inserted into the opposite ends of a glass tube 1.5 or 2 mm. internal diam. so that the ends are about 5 mm. apart. A hole is blown in the side of the tube between the ends of the wire, and when the spark passes the metallic vapour formed is blown out of this hole, and out of the region of electric force between the electrodes. The volume of vapour formed is not enough to distinctly exude from the hole at atmospheric pressure ; but the tube is arranged inside a receiver which can be exhausted, and the effect becomes conspicuous at a pressure of a few mm. of mercury. The vapour is shot out of the side hole in a distinct jet several mm. in length, visible by its own luminosity, which is seen to be continuous with that of the spark. When the metal is difficult to obtain in the form of wire, iron wires may be used, and a fragment of the volatile metal under investigation introduced into the gap, and in contact with one end of the wire. Vapours of the following elements are all found to give line spectra exclusively :—Na, Th, Ca, Zn, Cd, Hg, As, Mg, Pb, Se, S, P, I. Details of the glow appearances are also given. The effects obtained with the common gases H, N or air, O, and CO , are next described. As a result of these

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experiments it is concluded that the luminosity of the electric discharge survives the current not only in metallic vapours but also in the vapours of non-metals and in the permanent gases. It fades away in a continuous manner, and without immediate change of spectrum when the current ceases. Sometimes, however, a change of spectrum eventually results from unequal decay of the lines. These effects, which last less than $1/1000$ of a second, are distinct, not only in degree but in kind, from the afterglows in nitrogen, in gaseous mixtures containing oxygen, and in gaseous mixtures containing hydrogen, previously investigated. These have durations extending in some cases to several minutes, and their spectra are from the first radically different from those of the exciting discharges. As previously shown, they are due to secondary chemical actions of substances produced by the discharge.

A. E. G.

860. Selective Absorption of Electric Waves. W. Romanoff. (Ann. d. Physik, 40. 2. pp. 281-296, Feb. 4, 1918.)—The absorption of electric waves in alcohols is determined by the same method as that used by Zeeman and Eichenwald [see Abstracts Nos. 141 (1896) and 47 (1898)]. A wire system carrying the waves runs through the liquid of which the absorption is required and a thermo-element bridges the wires. From the ratio of two galvanometer deflections given by the thermo-element when placed at two points a known distance apart the absorption is determined. Care is taken that there are no interference effects due to reflected waves and that the galvanometer circuit is shielded from all stray electric effects. The wave-lengths vary from 50 to 100 cm. In every case the results show a strong dependence of the absorption on the wave-length. Maxima and minima of absorption are clearly observed, but the damping of the waves does not allow the absorption bands to appear very distinctly.

T. P. B.

861. Diffraction and Secondary Radiation with Short Electric Waves. A. D. Cole. (Phys. Rev. 1. Ser. 2. pp. 2-15, Jan., 1918.)—An experimental research which may be summarised as follows :—(1) A study was made of the distribution of radiant energy with several arrangements of electric wave apparatus likely to furnish diffraction effects, including the opaque edge and slits. The effect of the screens increased the energy received at certain points and some cases analogous to diffraction bands were found. (2) The effect of shifting a pair of "screens" along the radiation axis was also noted. (3) The effect of a gradual change in the width of an opening through which radiation passed was studied for two points on the axis. Very little energy passed when the opening was less than a quarter wave-length; with openings greater than one and a half wave-lengths more energy appeared beyond than when no screens were used. (4) Some resonance and interference results were obtained and are shown by curves. (5) Large absorption or obstruction effects were found when either a thick or a thin wire was placed at any point along the radiation axis if its length were parallel to the electric force. A flat strip reduced the intensity even more when placed edgewise than when broadside to the radiation. (6) When such a wire or strip was moved laterally by short steps from a central position strong maxima and minima were shown at the receiver. (7) One of Righi's "secondary radiation" experiments was repeated with the somewhat different apparatus here employed and his result verified. [See Abstract No. 820 (1911).]

E. H. B.

862. Radiation and Energy Dissipation of Electric Spark in High-frequency Circuit. H. R. v. Trautenberg. (Ann. d. Physik, 40. 2. pp. 249-260, VOL. XVI.—A.—1918.

Feb. 4, 1913.)—The radiation from an electric spark in an oscillation circuit is determined by means of a thermopile of special construction, which is standardised by means of a Hefner lamp. The total energy dissipated is determined by a calorimetric method. The heat developed in the electrodes is determined by means of a thermo-element. It is found that the radiation from a magnesium spark-gap is proportional to the product of the charge on the condenser and the discharge potential, other factors being constant. It is twenty times as great when sodium is used as electrode material as when silver is used. The radiation amounts to about 9 % of the total energy dissipated with a magnesium spark-gap. The energy dissipated depends on the length of gap in a manner analogous to that given by the Ayrton formula for the electric arc. The radiation- and chemical-energy dissipation of each electricity carrier appears to be about 10^{-11} erg. T. P. B.

863. *Electric Oscillations in a System of Three Coupled Condenser Circuits.* F. Müller. (Jahrbuch d. Drahtlosen Telegraphie, 6. pp. 885-892, Jan., 1913.)—This is the experimental part of a paper of which the theoretical part has already been abstracted [see Abstract No. 1744 (1912)]. Resonance curves of the oscillations in all three circuits are given, and these confirm the theory. An ordinary spark-gap, varying in length from 2 mm. to 8 mm., is used in the primary circuit. Impact excitation takes place in most cases both when the three circuits are in resonance and when only the first and third are. The best coupling for impact excitation of the third circuit when the second circuit is out of tune is found by experiment. When it has been found it is shown to be independent of the length of the primary spark, unlike impact excitation by Wien's method. T. P. B.

864. *Demonstration of Resonance Curves.* F. Kock. (Deutsch. Phys. Gesell., Verh. 14. 14. pp. 701-708, 1912.)—The author describes a somewhat modified form of his arrangement for recording resonance curves [see Abstract No. 1216 (1911)]. In the present apparatus a variable condenser, whose movable blades are rotated by means of an electric motor, is now used to bring the circuit into resonance each half-revolution, and a moving-coil galvanometer is arranged as an oscillograph in place of the Gehrcke tube formerly used. The beam from the galvanometer mirror impinges on to a mirror which is moved to and fro on a vertical axis by means of a crank on the condenser spindle. The rocking mirror furnishes the abscissæ, while the galvanometer coil, which has its axis horizontal, gives the ordinates. There is a semicircular slip-ring by means of which one of the resonance positions is suppressed (to avoid overlapping images). Some oscillograms obtained in this way are reproduced in the paper. L. H. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

865. *Preliminary Note on the Electron Atmospheres of Metals.* R. W. Wood. (Phil. Mag. 24. pp. 816-822, Aug., 1912.)—The author's experiments arose from an observation that a "half-silvered" quartz plate, having cross rulings 0.11 mm. apart, had an electrical resistance practically the same as that of an unruled film, although the cuts went clear through the film. The most suitable material for flat surfaces at minute distances apart was found to be speculum metal in the form of flats. Lycopodium spores allowed to settle on one plate

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and then squeezed between the two surfaces gave quite considerable readings on a galvanometer. Similar results were obtained when the flats were separated with very small flakes of thin mica, thus excluding any possibility of conduction due to absorbed moisture. With the plates between 20 and 80 wave-lengths apart, metallic conduction commences with 1 volt of applied potential. It appears to the author that the separation can be much greater when mica flakes are present than when the gap is quite free from all material.

L. H. W.

866. Phase Factor of Coils in Resistance Boxes. W. Hüter. (Ann. d. Physik, 40. 2. pp. 381-386, Feb. 4, 1918.)—A description of measurements, by Giebe's bifilar inductance bridge, of the effects of inductance and capacity in medium-sized coils in resistance boxes. The coils dealt with have resistances from 20 to 500 ohms, and were wound on the Chaperon system. The results are given in the form of values of the "Phase Factor" ($L/R - CR$), where R, L, and C are the resistance, self-inductance, and effective capacity of the coil.

F. E. S.

867. Note on the Energetics of the Induction Balance. J. P. Dalton. (Phil. Mag. 25. pp. 56-60, Jan., 1918.)—In the generalised induction balance in which each arm contains resistance, inductance, and capacity, (1) the steady balance is conditioned by the usual Wheatstone relationship between the resistances, (2) an approximate impulsive balance is given by zero integral extra current in the galvanometer, and (3) a true impulsive balance necessitates zero extra current in the galvanometer at any time. The author shows how the ordinary solutions can be very readily obtained by a general energy theorem due to Heaviside.

A. R.

868. Method of Charging Electrometer Needle. A. H. Erikson. (Le Radium, 10. p. 24, Jan., 1918.)—With a quartz suspension of a quadrant electrometer it is difficult to keep the needle continuously charged. In the present note a method of accomplishing this is described. A hollow cylinder containing polonium or other α -ray source and at a high potential is arranged so as to embrace the upper part of the needle which lies just above the quadrants. By this means an ionisation current passes into the needle and keeps it at the same high potential as the cylinder. A screen is arranged between the cylinder and the quadrants so that the working of the electrometer is not disturbed by the ionisation.

E. M.

869. Use of the Quadrant Electrometer for Measuring Large Resistances whether Variable or Polarizable. P. Vaillant. (Journ. de Physique, 8. Ser. 5. pp. 86-46, Jan., 1918.)—The author discusses the limitations of the quadrant electrometer for a direct current. In the case of resistances which polarise the current or which vary rapidly it is advisable to substitute alternating currents. The latter method, however, has its limitations. The author then describes a quadrant method for the study of resistance variation due to any cause whatever.

H. H. Ho.

870. Resistance of Bubbles in a Liquid. P. Vaillant. (Comptes Rendus, 156. pp. 807-810, Jan. 27, 1918.)—Discusses mathematically the great increase

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of electric resistance of a column of liquid when polarised, and thence deduces a method of measuring the resistance of a bubble. E. H. B.

871. Potential and Electromotive Force. W. Lenz. (Archiv f. Elektrotechnik, 1. pp. 888-893, 1913.)—A discussion of the physical relations between these quantities, using a hydro-dynamical analogy. F. T. C.

ALTERNATING CURRENTS AND MAGNETISM.

872. Susceptibility of the Binary Alloys. I. Antimony-Bismuth and Antimony-Zinc. K. Honda and T. Soné. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 11-16, Jan., 1913.)—The beginning of a systematic research on the para- and dia-magnetic binary alloys. The method was that of Curie [see Abstract No. 1935 (1910)]. In the first case, as the percentage of Bi in the alloy increases from 0 to 100, the susceptibility changes in an almost linear manner from -0.851×10^{-6} to -1.382×10^{-6} . In the second case there are three eutectic points in the range, and the susceptibility has the values -0.851×10^{-6} for 0 per cent. of Zn, -0.804×10^{-6} for 35.48 per cent. Zn, and -0.145×10^{-6} for 100 per cent. Zn; the curve consists of two nearly straight branches between these points. [See also Abstracts Nos. 1516 (1910) and 1113 (1912).] G. E. A.

873. Additivity of Diamagnetism in Compounds. P. Pascal. (Comptes Rendus, 166. pp. 828-825, Jan. 27, 1913.)—Taking the coefficient of magnetisation of water as -7.2×10^{-7} , the author calculates the absolute values of the atomic coefficients of magnetisation of a number of elements from the coefficients of simple organic compounds. The calculated values thus obtained are in close agreement with the results of direct measurements made by various investigators on the elements themselves. When the above method of calculation is extended to metals, use being made of organo-metallic compounds, it is found that the atomic coefficient of a diamagnetic metal is not constant but diminishes as the molecular weight of the organo-metallic derivative containing it increases. But, in any homologous series of such compounds, e.g. that of mercury or tin derivatives, the value for the metal diminishes towards a limiting value which agrees almost exactly with the coefficient for the metal determined directly. Hence, with metals difficult to obtain pure, it is possible to ascertain the coefficients of magnetisation from those of their organo-derivatives. [Erratum, Ibid. p. 586, Feb. 17, 1913.]

T. H. P.

874. Determination of the Magnetisation Coefficient of Water. P. Sève. (Journ. de Physique, 8. Ser. 5. pp. 8-29, Jan., 1913. Paper read before the Soc. franç. de Physique, July, 1912.)—The absolute value of the magnetisation coefficient of water has become important, since recent researches upon the effect produced by a magnetic field on various bodies require water as a standard for purposes of calculation. Curie's value is usually adopted, viz. $\alpha = -0.79 \times 10^{-6}$. The absolute value is especially useful in the case of feebly magnetic substances. The author discusses three previous methods due to Faraday, Gouy (the cylinder method improved by Wills), and Quincke, giving comparison values, and thereby showing the necessity for a new determination. Quincke's level method was finally adopted. Details are given as

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to the magnetic fields employed and their evaluation. The conclusion drawn from the determinations is that corrections are necessary wherever reference has been made to Curie's values.

H. H. Ho.

876. Theory of Magnetic Hysteresis. G. Vallauri. (Phys. Zeitschr. 14, pp. 118-120, Feb. 1, 1913. N. Cimento, 5. Ser. 6. pp. 41-46, Jan., 1918.)—Deduces the hysteresis curves of iron from Weiss's theory of ferromagnetic substances by a method analogous to that of Kunz [Abstract No. 1444 (1912)], but with correction of an error, which reduces the divergence between the theoretical and observed values of the hysteresis work from 68 per cent. to 82 per cent.

E. E. F.

876. Electron Theory of Magnetism. E. H. Williams. (Univ. of Illinois, Bull. 10. No. 10. pp. 8-64, Nov. 4, 1912.)—A summary of the work done on this subject. It is divided into four parts, entitled respectively:—(1) Essential features of the electron theory of magnetism. (2) Experimental determination of the magnetic properties of crystals. (3) Effect of temperature upon the magnetic properties of bodies. (4) Experimental evidence in favour of the electron theory of magnetism.

E. H. B.

877. Sun-spots and Terrestrial Magnetic Phenomena (1898-1911). A. L. Cortie. (Roy. Astronom. Soc., M.N. 78. pp. 148-155, Jan., 1918.)—In a former paper [see Abstract No. 701 (1918)] the mean seasonal variation in magnetic storms was attributed to the inclination of the sun's axis to the plane of the ecliptic and the position of the earth relative to the sun-spot zones. Selecting now the specially violent magnetic storms during the above period, a comparison is made between the times of their occurrence and the associated sun-spots. Certain peculiarities are evident. For instance, the year of maximum spots, 1905, was singularly free of magnetic storms. Tables are given of the magnetic data, areas, and positions of spot groups, etc. An important conclusion is that the most effective position of a spot group is entirely independent of the central meridian of the sun, although this relationship has been formulated by other observers. The westerly position appears to be more advantageous than the eastern. The characteristics of sun-spots accompanying the greater magnetic storms appear to be great irregularity of structure and rapid change, indicating great solar activity. The ratio of umbral area to the whole spot area is greater for spots associated with magnetic storms.

C. P. B.

RADIOLOGY AND ELECTROPHYSIOLOGY.

878. Use of very Soft Röntgen Rays in Radiography. T. Nogier. (Archives d'Él. Médicale, 21. pp. 168-164, Feb. 25, 1918.)—Wood is very transparent to Röntgen rays of ordinary hardness, and it has been found almost impossible to make use of radiographs for its localisation when embedded in the tissues. Extremely soft rays of scarcely one degree Benoist are obtained by use of the special bulbs of Grisson and Bürger, the positive pole of the coil being connected to the anode instead of, as is usual, to the antikathode. The plates obtained with this apparatus contain good detail of the soft parts, but of course the bones give an almost opaque image. Small splinters of wood, even in the thickest part of the hand, can be readily distinguished.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

879. *Supposed Synthesis of Neon.* W. Ramsay, J. N. Collie, and H. S. Patterson. (Chem. News, 107. pp. 78-80, Feb. 14, 1918. From a Press report of a meeting of the Chemical Soc., Feb. 6, 1918.)—To find whether there was any transmutation due to β -rays, Ramsay broke old X-ray bulbs, and found traces of helium, neon, and argon. On heating them to 800°C . and collecting the gases, he found the spectra of He and Ne. Neon might conceivably be produced by the combination of helium and oxygen. Collie described some results of bombarding fluorspar and other substances with cathode rays, Ne being produced. That this Ne leaked in through the glass from the air was rendered improbable by surrounding the vacuum tube with Ne, which produced no distinct difference. On surrounding it with another vacuum tube, helium was found in the second tube. Patterson found that this helium, mixed with oxygen, gave neon ($4 + 16 = 20$). The main hypothesis available for explaining these results, and the precautions taken are discussed. **J. J. Thomson.** (Nature, 90. pp. 645-647, Feb. 13, 1918.)—Adduces the difficulty of freeing glass from traces of H and other gases as an argument against the synthesis of neon. The glass of the vacuum tube may be heated to melting-point, the gases dried with charcoal and liquid air, and the incoming gases freed from hydrogen with the utmost care, the H lines will still be got by the positive-ray method, even when the bulb has been running for several hours a day for nearly a year. The only exception is when oxygen is kept continuously running through the tube. It then combines with H, and disperses the H lines as it does those of Hg. This production of H seems to be analogous to the production of He, Ne, and the new gas X_2 . Almost any substance, when bombarded for several hours with cathode rays, yields X_2 . The X_2 line is, as a rule, first accompanied by the He line, and somewhat less frequently by the Ne line. Lead may be evaporated until neither X_2 nor He can be detected in the vapour. But these will reappear when bombarding the remainder with cathode rays. E. E. F.

880. *Chemical Constants of Gases.* O. Sackur. (Ann. d. Physik, 40. 1. pp. 87-106, Dec. 31, 1912.)—The chemical constants of various gases are calculated according to the formula $C = (S' - C_p + R \log R)/2.8R$, where S' is the entropy constant. The values so calculated include H_2 , -2.74 ; N_2 , 0.88 ; O_2 , 0.48 ; H_2O , -1.18 ; CO , 0.85 ; and CO_2 , 1.18 . They are smaller than the values given by Nernst, which, however, were based upon estimates of specific heat revised later by Nernst himself. The new values are applied to the calculation of vapour pressures, and give good results to a first approximation, both for molecules composed of identical atoms and molecules of substances containing several elements. More material is required for very high and very low temperatures. E. E. F.

881. *Influence of Impurities on Muntz Metal.* F. Johnson. (Engineering, 95. p. 288, Feb. 28, 1918.)—Experiments have been made with a view to placing on record the exact nature of the brittleness of Muntz metal made from certain brands of copper. The influence of small quantities of arsenic, antimony, and bismuth on the forging and cold-rolling properties have been

investigated ; the results of which tests show that antimony is more detrimental than arsenic, and bismuth does not exercise the deadly effects in Muntz metal it does in copper. Maximum brittleness is, however, obtained in the combined presence of small quantities of arsenic and antimony. F. C. A. H. L.

882. Deformation of Plastic Alloys and their Behaviour on Subsequent Reheating. A. Portevin. (Comptes Rendus, 156. pp. 820-828, Jan. 27, 1918.)—By very slow solidification of molten alloys it is possible to obtain very large and homogeneous individual crystals. From such a crystal, containing 97.8 per cent. of copper and 2.2 per cent. of aluminium, a test-rod was prepared having a length of 17 mm., and its bases being rectangles 12.8×7 and 9.5×7 mm. respectively. An axial pressure of 600 kg. produced deformation of this rod, "slip-bands" being formed on the lateral faces, these being on any one face rigorously rectilinear and parallel. The first "slip-bands" are in a plane which is not parallel to the bases of the rod, the normal to the plane making an angle of 88° with the direction of application of the compressing force ; this plane is one of the planes of sliding of the crystal and the components of the deforming pressure normal, and parallel to it are 5.2 and 8.4 kg. per sq. mm. respectively. If the elastic limit is regarded as corresponding with the first appearance, under a magnification of 200 diameters, of slip-bands, this limit varies considerably with the direction of the deforming force. With a mass of an alloy, which always consists of an agglomeration of variously orientated crystals, the phenomenon of deformation assumes great complexity. When the deformed test-rod was subsequently heated at 800° for 8 hours, it underwent disintegration into many small parts, the number of these apparently depending on the magnitude of the deforming force applied. T. H. P.

883. Strengths of Thermally-treated Metals and Alloys. W. Müller. (Metall. u. Erz, 10. pp. 219-280, Jan. 22, 1918.)—Compilations and diagrams of the results of tests on the strengths (breaking strength, elastic limit, elongation) of metals heated to different temperatures and slowly or rapidly cooled. The metals and alloys dealt with are copper, zinc, nickel, aluminium, copper-zinc, copper-tin, copper-aluminium, copper-nickel, aluminium-magnesium, copper-zinc-tin, copper-zinc-nickel, and the chief authors quoted are Weidig 1911, Matweeff 1911, Martens, Grard, Guillet, Heyn, Baumann, Diegel. H. B.

884. Tensile Strength of Copper-Zinc Alloys. J. M. Lohr. (Journ. Phys. Chem. 17. pp. 1-25, Jan., 1918. Paper read before the 8th Internat. Congress of Applied Chemistry, New York, Sept., 1912.)—Gives the results of determinations of the tensile strengths of cast brasses containing 47.5 to 100% Cu. There is a slight increase in tenacity with the first addition of zinc to copper, after which the values remain almost constant throughout the α field, that is, to about 84% Zn. The max. tensile strength occurs at about 55% Cu, and is about 71,000 lbs. per sq. in. The β alloys give the highest tensile strengths. The variations in the tensile strengths agree very closely with the constitution of the alloys. Curves are given in which the results are compared with those obtained by Thurston, Mallet, Charpy, and the Alloys Research Committee. C. O. B.

885. The Acicular Constituents of Alloys. Special Bronzes of Aluminium and Tin. F. Robin. (Bull. Soc. d'Encouragement, 119. pp. 12-41, Jan., 1918.)—There are two types of microstructures consisting of interlocking
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laminae or needles : the Widmanstätten structure characteristic of prolonged annealing, and the martensitic structure characteristic of quenched solid solutions. A systematic study of the hardening, tempering, and annealing of aluminium and tin bronzes and a number of their ternary alloys has been undertaken with a view to a determination of the conditions under which the martensitic structure is produced and dissipated. In aluminium alloys the size of the needles obtained on quenching increases with the content of aluminium up to about 14 per cent. By quenching such an alloy from $1000^{\circ}\text{C}.$, and subsequent tempering at various temperatures, it is possible to reproduce the sorbitic, granular, and laminated pearlitic structure of steels. The austenitic structure cannot, however, be obtained. By prolonged annealing at $800^{\circ}\text{C}.$ the δ and α constituents give rise to the Widmanstätten structure locally. In tin bronzes the martensitic structure is not so easily produced, but can be obtained by quenching a 25 per cent. alloy from a very high temperature (just below the solidus). Quenching from the point of fusion produces large grains which are crossed with striations, but can nevertheless be compared with austenite. Tempering is much more rapid than in the case of the aluminium alloys. Similar experiments have been made on ternary alloys containing zinc, tin or aluminium, antimony, silicon, magnesium, arsenic, and the areas of alloys yielding the martensitic structure are indicated on the ternary equilibrium diagrams. The question of metallographic equivalence of the various metals is discussed, and laws are deduced for their determination. Excellent micrographs illustrate the paper and are discussed in detail.

F. C. A. H. L.

886. *Influence of Divorce Annealing on the Mechanical Properties of Low Carbon Steel.* H. M. Howe and A. G. Levy. (Amer. Inst. Mining Engin., Bull. 78. pp. 1-85, Jan., 1918.)—In passing through the critical range, the change occurring in steel takes place in two stages: (1) the transformation in which the ansténite is split up into cementite and ferrite, and (2) the structural change in which the ferrite and cementite coalesce into separate large masses. While the first change is rapid, the second one is relatively slow. The process by which the cementite and ferrite are caused to coalesce severally and completely has been called "divorcing annealing" by the authors. Earlier evidence indicates that such annealing increases the ductility, but the results are contradictory as regards the effects on elastic limit. Steels containing 0.21 per cent. carbon and 0.05 and 1.19 per cent. manganese respectively were cooled at various rates from $900^{\circ}\text{C}.$, while others were held in the upper part of the divorcing range (675 – $710^{\circ}\text{C}.$) for varying times, after which the mechanical properties and microstructures of the test pieces were examined. Etching with sodium picrate reveals the presence of structurally free cementite in a specimen which had been held at $685^{\circ}\text{C}.$ for $28\frac{1}{2}$ hours. The first prolongation in the rate of cooling from iced brine quenching to air cooling has the greatest influence on the mechanical properties. The temperature of most active divorce is about $685^{\circ}\text{C}.$, and maintaining at this temperature decidedly softens the metal and lowers its yield-point and tenacity. Further prolongation of the heating has no further influence on the elastic limit, but increases the softness. A given degree of divorcing with its attendant softening is obtained more quickly by a stay in the upper part of the divorcing range, followed by as rapid a cooling as possible compatible with avoidance of undue stress, than by a slow cooling from the critical range. Hyper-eutectoid steel would be expected to behave differently because of the presence of pro-eutectoid cementite, but experiments indicate that prolonged divorcing

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annealing may increase the ductility of hyper-eutectoid steel to a degree far beyond that observed for hypo-eutectoid steel. It loses its ductility abruptly between 800° and 900° C., but a higher temperature is required to affect the elastic limit and tenacity to any considerable extent. F. C. A. H. L.

887. Inverse Occurrence of Solid Phases in the Iron-Carbon System. A. Smits. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 871-880, Oct. 24, 1912.)—A highly theoretical paper dealing with the inverse appearance of solid phases in the iron-carbon system—a phenomenon which had previously only been met with in the cerium sulphate-water system.

F. C. A. H. L.

888. Progress in Metallography, 1909-1911. E. Heyn. (Rev. de Métallurgie, 9. pp. 984-982, Dec., 1912.)—Contains a list of references to 540 original papers.

889. Wittorf's Iron-Carbon Diagram. B. Stoughton. (Amer. Inst. Mining Engin., Bull. No. 74. pp. 227-237, Feb., 1913.)—The author briefly reviews Wittorf's work, which has already been dealt with in Abstract No. 1899 (1912). Attention is called to certain discrepancies between Wittorf's work and that of Ruff [Abstract No. 1619 (1911)].

F. C. A. H. L.

890. Formation of Nitric Oxide in the High-tension Arc. F. Fischer and E. Hene. (Ber. Deut. Chem. Gesell. 45. pp. 8652-8658, Dec. 28, 1912. Chem. News, 107. p. 144, March 20, 1913. Abstract.)—When pure oxygen is sparked and then mixed with nitrogen, six times more nitric oxide, NO, is produced than when the nitrogen is sparked and mixed with oxygen; it is also better to spark the air (instead of oxygen) than the nitrogen. When air is sent through a high-tension arc produced in a cooled quartz tube and then at once mixed with oxygen, air, or nitrogen, the resulting volume percentages of NO are 7.8, 7.4, and 5.9. The yield of NO obtained in a Siemens ozoniser at different temperatures increases with rising temperature (up to 700° C.), because the velocity of the reaction is increased before the ozone is destroyed by the heat. It is concluded that it is the oxygen, and not the nitrogen, which is activated by the high-tension discharge. The dissociation of the oxygen molecule takes place within the arc and is endothermic; without the arc exothermic processes lead to the recombination of the oxygen atoms to molecules and to ozone and to the formation of nitric oxide; the NO is formed either by direct reaction between active oxygen and nitrogen or by the reaction between ozone and nitrogen. Technically oxygen (not air) should be passed through the arc playing between magnetite electrodes, and the gas then rapidly be mixed with nitrogen and cooled, the oxygen to be fractionated by the Linde method.

H. B.

891. Chemical Reactions at very Low Pressures. I. Langmuir. (Amer. Chem. Soc., Journ. 35. pp. 105-127, Feb., 1913.)—A tungsten wire, heated in oxygen at very low pressures, begins to oxidise at about 800° K. (abs.), the brown or blue coating of the oxide, WO₃, being volatilised without dissociation at about 1200° K. Above the latter temperature, oxygen at pressures below 0.02 mm. acts on a tungsten wire at a rate which is strictly proportional to the pressure of the oxygen and to the surface of metal exposed. The rate increases with rise of temperature as rapidly as is the case with most chemical reactions at these high temperatures. No

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fatigue effect can be observed, and the past history of the wire does not influence the results. The experimental conditions employed are such that: (1) a molecule of oxygen can strike the filament only once before returning to the surface of the bulb; (2) the velocity of the oxygen molecules is not affected by the temperature of the filament, the metal thus reacting with a gas at a totally different temperature; (3) the product of the reaction, WO_3 , in diffusing away cannot influence the rate at which the oxygen comes into contact with the metal, as would be the case at higher pressures. The ratio, ϵ , of the observed rate of the reaction to the calculated maximum possible rate varies from 0.0011 at 1270°K . to 0.15 at 2770°K . Analysis of the experimental data according to the kinetic theory leads to the following conception of the mechanism of the reaction. The oxygen molecules which strike the filament do not react directly with tungsten atoms, but are first negatively charged by taking up an electron from the metal. On the average, about 80 electrons in the metal collide with the oxygen molecule during its contact with the metal, but only those electrons which have a velocity of $62 \times 10^4 \text{ cm. per sec.}$ or more succeed in charging the oxygen atoms. The number of electrons having such a high velocity is so small that only a few of the oxygen molecules impinging on the tungsten become negatively charged; thus at 1270°K . only one electron out of about 24,400 answers this condition, so that the number of oxygen molecules receiving a charge is about one out of a thousand. The negatively charged oxygen molecule is held by electrostatic forces to the positively-charged tungsten atoms, secondary reactions soon resulting in the union of the tungsten and oxygen atoms to form the oxide. This theory accounts for the observed values of ϵ between 1270° and 1770°K ., and for the fact that the value of ϵ is independent of the temperature of the oxygen. [See Abstract No. 528 (1918).]

T. H. P.

892. *Activity of the Ions and Degree of Dissociation of Strong Electrolytes.* G. N. Lewis. (Amer. Chem. Soc., Journ. 84. pp. 1681-1644, Dec., 1912.)—The author discusses more particularly the properties of strong uni-univalent electrolytes, with which alone the existing data permit conclusions free from ambiguity to be drawn. A very large number of chlorides, bromides, and iodides are equally dissociated, whilst nitrates, chlorides and bromates and salts of silver and of thallium are somewhat less dissociated. The degree of dissociation of uni-univalent salts is probably much smaller than commonly supposed. If it is assumed that the dissociation of potassium chloride is 74 per cent. at 0.1M, 82 per cent. at 0.05M, and 89 per cent. at 0.02M, then in all cases up to a few 0.01M, and probably in most cases up to 0.1M, the activity of the ions is proportional to the concentrations thus calculated. This view attributes the deviation of strong electrolytes from the mass law largely to a general increase in the mobility of the ions with the total ionic concentration, and differs essentially from the theory advanced by Franklin and Kraus and by Lewis and Wheeler. The latter theory regards the abnormalities of the conductivity curves for electrolytes as due to a change in the dissociating power of the solvent owing to the addition of a stronger electrophile as solute. According to the former explanation it is the velocity of the ions which does not obey the laws of the ionic theory, whilst, according to the latter, it is the degree of dissociation. Probably neither explanation alone is adequate, but the evidence here adduced in support of the view that the ions have a variable mobility in aqueous solution renders further investigation desirable.

T. H. P.

893. Relation between Ionisation by Kathode Rays and certain Chemical Effects. E. Jacot. (Phil. Mag. 25. pp. 215-284, Feb., 1918.)—This work was carried out in order to ascertain what proportion of the so-called chemical effect of kathode rays is a direct effect such as Schmidt presumed [see Abstract No. 461 (1902)], and what proportions of it result from purely thermal effects of the rays and from a primary chemical effect on the gas or gases in the discharge-tube. Investigation of the action of kathode rays on white phosphorus showed this to be of twofold character: a purely thermal effect of the rays, resulting in the formation of red phosphorus, and a more directly chemical effect due to action of the corpuscles on the nitrogen in the tube, followed by a reaction between the modified gas and the phosphorus. The latter effect is proportional to the equilibrium ionisation of the nitrogen, but the total number of active atoms or molecules in the gas is of a much higher order than the number of ions present in the gas at the instant of combination. The function of the ions may be to assist a combination which does not otherwise take place. More probably the activity of the gas is not directly due to its ionisation, but rather to an atomising effect of the kathode rays on the gas—the active product being monatomic nitrogen, and the total number of modified gas molecules showing an exact proportionality to the ionisation in the gas by the rays. The ionisation in nitrogen by kathode rays is shown to vary inversely as the kinetic energy of the rays, for rays of velocities varying from 2.92×10^9 cm. per sec. to 4.76×10^9 cm. per sec. The ionisation also varies linearly with the pressure over the range 0.063-0.025 mm. of mercury. T. H. P.

894. E.M.F.'s in Alcohol. III. Hydrogen Electrode in Dry and Moist Alcoholic Hydrogen Chloride. R. T. Hardman and A. Lapworth. (Chem. Soc., Journ. 101. pp. 2249-2255, Nov., 1912.)—The influence of water on the e.m.f. of the hydrogen electrode in alcoholic hydrogen chloride at 25° is of the nature required by the solvate theory of acids, the quantitative results being in agreement with the affinity values of water and alcohol deduced by chemical methods. Additional experiments have been made with reference to (i) the e.m.f.'s of hydrogen ion concentration cells with solutions of hydrogen chloride in absolute alcohol as cell liquids, and (ii) the influence of temperature on the disturbance produced in such cells by addition of water. With ordinary concentration cells the e.m.f. increases nearly in proportion with the absolute temperature; but cells in which a moist alcoholic solution of HCl is set up against a dry solution decrease in e.m.f. in agreement with the requirements of the solvate theory as applied to these solutions. The fall in the basic "water-value" of alcohol as estimated by means of the hydrogen electrode is of the same order as that deduced by chemical methods, but appears somewhat greater. [See Abstract No. 616 (1912).] T. M. L.

895. Electrolysis of Radio-active Substances. K. F. Herzfeld. (Phys. Zeitschr. 14. pp. 29-32, Jan. 1, 1918.)—According to v. Hevesy [Abstract No. 1605 (1912)] the relative amounts of radio-active substances deposited by the electrolysis of a highly dilute mixed solution depend only on the potential, and not on the quantity present. The author modifies Nernst's formula for the kathode potential $E = RT \log_e (P/p)$ into the formula $E = RT \log_e (P'p_1/p)$, where P' is the solution pressure of the deposited atoms of the substance, p the osmotic pressure of those in solution, and p_1 the osmotic pressure corresponding to those deposited. This is justified by the consideration that the number of molecules deposited in unit time is only independent of those

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already deposited when the whole electrode is covered with at least one molecular layer. Otherwise the number of ions redissolved is proportional to the surface covered, *i.e.* to p_1 . The author shows that this modified formula gives a close approximation to v. Hevesy's curve. E. E. F.

896. *Electrolytic Processes.* E. Grimsehl. (Phys. Zeitschr. 18. pp. 1199-1202, Dec. 15, 1912.)—A Pt-wire is fused into a glass tube and then cut off level with the end of the tube, and the surface of glass and metal polished. When used as kathode in the electrolysis of very dilute sulphuric acid at a voltage of 110-220 volts, under certain conditions a fine stream of hydrogen bubbles is blown out in a peculiar manner at right angles to the surface of the Pt. This particular phenomenon (called by the author the "spirt phenomenon") depends on the concentration of the acid and on the voltage; the higher the voltage the lower the concentration of the acid necessary. With 100 volts the acid must be at least 0.01 per cent. strength. With the same concentrations the velocity with which the hydrogen is blown out is the greater the higher the voltage. When the concentration and voltage are kept constant the current strength is directly proportional to the radius of the electrode, and examination with a lens showed that the gas bubbles came off from the periphery of the electrode. Similar phenomena may be observed when the electrode is used as anode. Using the electrode as kathode, it is found that the potential-fall between the anode and kathode is mainly in the neighbourhood of the latter, 95 per cent. of it being within 0.1 mm. of the kathode. In the next series of experiments the Pt-wire of the electrodes projected a few mm. from the glass tube. When the "spirt phenomenon" was taking place it was found that the stream of hydrogen was deflected by an electromagnet as if it were negatively charged, and the stream of oxygen as if positively charged; the electrolyte may be either sulphuric acid, hydrochloric acid, or potassium hydroxide. By using an alternating current for electrolysis, and feeding the electromagnet with direct current, it was possible to deflect in the opposite directions the hydrogen and oxygen evolved, and collect them in separate receivers. If an electrode of zinc, similar in shape to that of Pt, is dipped by itself in dilute sulphuric acid, the hydrogen evolved is not affected by the electromagnet. If, however, it is then connected, outside the cell, with a Pt electrode immersed in the same electrolyte, only a very slight stream of hydrogen is given off, and this behaves towards the magnetic field as if positively charged. The hydrogen evolved from the Pt electrode is negatively charged. Lecture experiments are described for the demonstration of (1) the electrolysis of solutions of zinc chloride, and (2) the alteration in concentration on the electrolysis of solutions of sulphuric acid. T. S. P.

897. *Passive State of Iron.* J. MacLeod-Brown. (Chem. News, 107. p. 15, Jan. 10, 1913.)—It is frequently asserted that, if part of an iron nail or wire is rendered passive, the remainder of the nail or wire also assumes this state. That this is not so may be shown as follows:—An iron nail, 8 in. long, is immersed to a depth of 1 in. in concentrated nitric acid. The nail is allowed to drain, and the other end immersed to a depth of 1 in. in dilute nitric acid, when it will be found to be active; the passive end remains passive. If the nail is lowered into the dilute nitric acid, passive end first, the whole of it becomes passive after a short time. Other experiments are described in which it is shown that when a passive iron nail is connected by means of a Pt or copper wire to a nail of ordinary iron, the two nails being
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immersed in dilute nitric acid, that part of the ordinary iron which dips into the nitric acid becomes passive after a short time, the passivity being produced by anodic polarisation. The author considers that the passive state is conditioned by some definite arrangement of the particles at the surface of the iron.

T. S. P.

898. *Time-lag between Electric Polarisation and Electrolysis.* A. Grumbach. (Comptes Rendus, 156, pp. 542-548, Feb. 17, 1918.)—If there be a time-lag between polarisation and electrolysis, a current-impulse of short duration should not evolve gas, though the same feeble current would liberate gas when acting for longer periods. The author confirms this by experimenting under the microscope with sulphuric acid and platinum wire electrodes, one very fine, closing the circuit for $1/12$ sec. by means of a drop-switch. When the fine electrode had a diameter of 0.1 mm., an e.m.f. of 0.86 volt did not evolve hydrogen with instantaneous currents, but an e.m.f. of 0.92 volt did; the difference vanished as the electrode was made finer (0.01 mm.). The figures for oxygen (0.1 mm.) were 1.07 and 1.28 volts.

H. B.

899. *Electrochemical Properties of Uranium X.* P. Rossi. (N. Cimento, 5. Ser. 6, pp. 5-14, Jan., 1918.)—Experiments on the electrochemical properties of uranium, both by electrolysis of solutions of its salts, and by immersing rods of various metals in them, show that the separation of U and UX is more difficult than for the elements of the radium family, which accords with the theory of Lucas [Abstract No. 1813 (1906)]. Contrary to this, however, UX is not more readily separable than U. Adding small quantities of other salts to the U solutions before electrolysis, e.g. CuSO_4 , NiSO_4 , or FeSO_4 , to a solution of uranium sulphate, AgNO_3 to a solution of uranium nitrate, or lead acetate to one of uranium acetate, a deposit is obtained on the anode having an activity due entirely to UX, which the author attributes to absorption, and on the kathode a deposit which is either almost inactive or has an activity due as much to U as to UX. [See also Abstract No. 1057 (1910).]

W. H. St.

900. *The Resistance of Electrolytes.* S. W. J. Smith and H. Moss. (Phys. Soc., Proc. 25, pp. 138-148; Discussion, pp. 143-145, Feb. 15, 1918.)—In some experiments shown before the Physical Society in 1911, Haworth demonstrated that the resistance of an electrolyte depended on the frequency of the alternating current used [Abstract No. 1437 (1912)]. The authors point out that the method used is unsound, and have performed test experiments by a simple and direct method, which depends upon simultaneous measurement of the voltage between the ends of a tube containing the electrolyte and of the current passing through it. The former was measured by means of an Ayrton-Mather electrostatic voltmeter connected to auxiliary electrodes, and the latter by means of a Duddell thermogalvanometer. In the cases examined, using a solution of potassium chloride, it was found that the resistance of the electrolyte was constant within 0.05 per cent., whether steady currents or currents of any frequency up to 2800 alternations per sec. were used.

T. S. P.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1913.

GENERAL PHYSICS.

901. *Apparatus for Measurement of Distance.* E. Hammer. (Zeitschr. Instrumentenk. 88. pp. 52-59, Feb., 1918.)—Describes an apparatus similar to a theodolite, but having two telescopes, one above the other, the axes about which the telescopes turn being slightly inclined to one another. The instrument was designed by J. Zwicky for distance measurements. For details and method of use the original paper should be consulted. A. W.

902. *Simple Method for determining the Densities of Powdered Minerals.* M. Billy. (Comptes Rendus, 156. pp. 1065-1067, April 7, 1918.)—In measuring the density of a powdered metal, etc., error is introduced owing to the presence of numberless small gaseous envelopes surrounding the solid particles. In order to avoid this, the author replaces the air held by the powder by carbon dioxide and weighs the substance, not in water, but in approximately normal potassium hydroxide solution, which has been previously boiled. The density of the alkaline solution alone is determined in the same way, the pycnometer being filled with carbon dioxide before the liquid is introduced. A special apparatus has been designed to facilitate these operations. The method was tested by the examination of powdered glass, the density of which had been measured prior to powdering. Whereas other methods give results accurate to about 1 part in 800, the author's method showed an accuracy of the same order as that of the balance employed, namely, 1 in 8000. It would therefore seem advisable to powder all solids before measuring their density, so that the absence of enclosed bubbles or fissures may be ensured. T. H. P.

903. *Law of Plastic Flow.* C. E. Larard. (Phys. Soc., Proc. 25. pp. 88-92; Discussion, pp. 92-94, Feb. 15, 1918.)—Strain measurements in the twisting to destruction at a uniform angular velocity of 0.1145 degree per sec. of a cylindrical bar of 0.82 % carbon annealed steel gave the following results. The torque had to be increased at a rate varying inversely as the time since the commencement of the test. In the equation $t + t_0 = ae^{T/t}$ t is time, and T is torque. t_0 is a small time constant, the value found being about 6 secs.,

which is not very material, as the total time of test was 42 mins. a is 8.28 and b is $1/80$. There is elastic strain proportional to the torque, up to the maximum. At very low and very high speeds of twisting the yield-point is suppressed. The yield-point in the ordinary case is raised by strain followed by slight warming. In the *discussion*, R. A. Hadfield said that records of the passage of a projectile through a plate showed that even at these high speeds of straining steel behaved much the same as in ordinary tests. R. Appleyard criticised the constants in the author's equation, and suggested some revised values. F. R.

904. *Anomalous Variation of the Rigidity of Phosphor-bronze*. H. Pealing. (Phil. Mag. 25. pp. 418-427, March, 1918.)—The modulus of rigidity of phosphor-bronze strips, as determined from torsional oscillation experiments is found to be less at light loads than at heavy, the variation being greatest in thin strips, very small in thick strips, and entirely absent in wire. With lapse of time under steady load the discrepancy tends to disappear, the rigidity levelling up to a value above the initial maximum. Amplitude and damping of the swing have no effect on the rigidity. Experiment disproves the suggestion that the strips have any bifilar properties whereby the restoring couple would vary as the weight supported. It was concluded that initial kinks in the strip had a negligible influence on rigidity, apparent or real. It was found that annealing the strips made them softer, but the restoring couple was substantially increased, being the same at all loads. This result supports the conclusion that the variation in rigidity is due to initial overstraining received in manufacture. This overstrain in rolling is located on the surfaces, and it was sought to counteract it by imposing excessive skin stresses by winding the strip round a narrow cylinder. On the spiral strip thus obtained being straightened out its rigidity was found to be uniform, being unchanged at high loads, and greatly increased at low loads. The effect was permanent, the conclusion being that the overstraining in manufacture has been neutralised by that caused in the test. E. J. S.

905. *Resilience*. (Rev. de Métallurgie, 9. pp. 1174-1181, Dec., 1912.)—An apparatus has been designed in the Metal-testing Department of the Cie. des Chemins de fer Paris-Lyon-Méditerranée for making shock tests on notched bars and for measuring the energy left in the tup after fracture of the specimen. Experiments made with this apparatus show that the resilience is always less when the tup is caused to fall from a height just sufficient to break the specimen than when it falls from a greater height. The resilience is inversely proportional to the weight of the tup, so that the product of the height and resilience is constant. With equal sections the angle of the notch has a considerable influence on the resilience of a metal. F. C. A. H. L.

906. *Effects of Holes and Semicircular Notches on the Distribution of Stress in Tension Members*. E. G. Coker. (Phys. Soc., Proc. 25. pp. 95-105, Feb. 15, 1918.)—For a tie with a circular hole the values of $(p_x - p_y)$, p_x and p_y being the principal stresses, obtained optically agree fairly with theory if the diam. is not over $\frac{1}{4}$ the width of plate. A formula obtained for the max. stress is $p_{\max} = 6c^3/(2c^3 + 2c^2 + c + 1)p_{\text{mean}}$, where c = ratio of width of tie to diam. of hole. If c is much over unity $p_{\max} = (8c^2 + 1)p_{\text{mean}}$. With 2 semicircular notches symmetrical with the centre-line and on the cross-section Leon gives the approximate solution $p_x = \frac{1}{2}p(2 + a^2/r^2 + a^4/r^4)$ and $p_y = \frac{1}{2}p(a^2/r^2 - a^4/r^4)$. Determination of $p_x - p_y$ shows that the max. values.

agree with the formula for notches with max. radius about $\frac{1}{4}$ of width of member. A proposed formula for determining the max. stress is—

$$p_{\text{max.}} = 12c^3 / (6c^3 + 4c^2 + c + 1) p_{\text{mean.}}$$

[See Abstract No. 296 (1911).]

E. J. S.

907. *Thermoelectric Indication of Fatigue as a Method of Testing.* T. R. Lawson and J. A. Capp. (Rev. de Métallurgie, 10. pp. 174-198, Jan., 1918.)—The determination of the elastic limit by means of a thermo-couple has attracted the attention of several investigators, and it has been shown that below the elastic limit, a bar of metal in tension absorbs heat, while above the elastic limit heat is generated by the friction of the particles during gliding over each other. It has also been stated that the thermal limit of proportionality is slightly lower than the true limit, and that below the thermal limit the variation of temperature is directly proportional to the effort. With the object of applying the phenomenon as a method of determining the elastic limit of small and other samples which do not permit of the application of the ordinary methods, the authors have made tests on various steels, cast-iron, and various copper alloys. Tests were made in an ordinary tensile testing machine, the stretch being observed by an extensometer, and the temperature variation by means of a copper-constantan couple pressed into contact with the specimen by a rubber band, and connected to a sensitive galvanometer. Examination of the large number of curves reproduced shows that in every case there is a discontinuity in the temperature curve in the region of the yield-point, but that generally speaking the thermal limit is somewhat higher than the true yield-point. Below the yield-point some of the thermal curves are inexplicably irregular, but in no case are they represented by straight lines. The investigation is not regarded as complete, but is to be continued by the authors.

F. C. A. H. L.

908. *A.E.F. Recommendations for Units and Symbols.* (Elektrotechn. Zeitschr. 84. pp. 808-810, March 18, 1918. Deutsch. Phys. Gesell., Verh. 15. 5. pp. 148-150, March 15, 1918.)—Contains amendments to Section VII of the Committee's Report [Abstract No. 649B (1910)]; part A remains unaltered. A revised list of units, abbreviations, and symbols is given, and is followed by a report by K. Scheel and K. Strecker. In the mensuration section, it is suggested that $\lambda = 0.001$ millilitre ($= 0.001$ c.cm.). A symbol for 100 kg. is needed; dz. (Doppelzentner), is unsatisfactory; q. (Quintal), is much used in France and Italy, but is not suitable for German or English use; and hkg. (hecto-kg.) is not to be recommended, but there appears no serious objection to dt. (dezitonne). By γ is to be understood 0.001 mgrm. The abbreviations st., mn., sk., have not received approbation. St. cannot become an international abbreviation (for hour), and yields inconvenient compound abbreviations. It is recommended that the same abbreviation be used for time periods and time instants, the two cases being distinguished by writing the symbols on and above the line respectively: h . is to be used for hour and s . for second; m . may be used for minute where there is no doubt as to its significance. It is not wise to use the same signs for time minutes and seconds as for angular minutes and seconds and the use of simple figures, (e.g. 4.50.10 for 4h. 50m. 10s.), may lead to misinterpretation, though it is permissible in time-tables, etc. The legal and international gramme cannot

be renamed, hence, to distinguish between mass and force units, the latter must be given a distinctive name. Budde has recommended the term *bar*. In 1900, the Physical Congress (Paris) resolved to denote unit pressure on unit area by *barye*; about the same time, Bjerknes called 10^6 dynes/cm.² a *bar*. The new unit is much used in oceanography and meteorology. The International Aero Commission (May, 1912) resolved to adopt this unit. Further, T. W. Richards (1904) recommended that 1 dyne per cm.² be termed a *bar*, and the latter name has been used in various scientific works. Under these circumstances it is doubtful whether *bar* can safely be used as the name of the force unit, but this course is provisionally adopted. 1 *kilobar* = weight of 1 kg.; 1 *megabar* = weight of 1 metric ton (*tonne*). It is expected that the distinctive nomenclature for the weight of the gramme, etc., will avoid innumerable difficulties. The *dyne* is inconveniently small for use in technical calculations, and the *megadyne* is not large enough in many cases. Grüber suggests that the force which accelerates 1 tonne mass at 1 m./sec.² be termed 1 *vis* (v.); this unit = 10^6 dynes and = weight of 100 kg. (approx.) ≈ 102 kb. The corresponding work unit is the *vismetre* (vm.); and the power unit, the *vismetre per sec.* which is familiar under the name kilowatt. The new force unit fits well in the electrotechnical units derived from the absolute mass system. Grube wishes to distinguish between static and dynamic forces, holding that the two are not of like dimensions; the present recommendations do not support this distinction, but regard 1 v. ≈ 102 kb. as a correct equation. Taking the *bar* as the technical force unit, the unit of work = 1 kilobar-metre = 1 kbm. : (mkb., though uniform with m.kg., might be read as 10^{-3} kb.). Stress units are altered in accordance with the altered force unit; instead of kb. mm.⁻² is recommended kb./mm.², this being equally correct and easier to write, read and interpret. The distinction between Cal. and cal. is insufficient, and it is recommended that the gramme-calorie be represented by cal. and the kg.-calorie by kcal. Reasons for not calling the calorie the *Wärmeeinheit* (heat unit) are given in the earlier treatment of Section VII (*loc. cit.*). Light units have not roused much interest; one suggestion had been that Lux be not abbreviated. The ohm is to be denoted by \oslash , the forked arrow indicating the electrical nature of the unit. For ampere-turns use Aw; watt-hour, Wh; ampere-hour, Ah. R. E. N.

909. *Four-dimensional Theory of Gravitation*. J. Ishiwara. (Tôhoku Math. Journ. 8. pp. 9-14, March, 1918.)—Gives a four-dimensional theory of gravitation based upon the electromagnetic theory of Minkowski and Sommerfeld [see Abstracts Nos. 1468 (1911) 785 (1912)]. The electromagnetic equations differ from those of Maxwell in that the velocity of light is not a constant, but a function of the space-time co-ordinates. The author arrives at a formula for the propagation of transverse electromagnetic waves from which the curvature of a ray of light in the gravitational field may be calculated. E. E. F.

910. *Influence of the Support on Pendulum Observations*. E. Esclangon. (Comptes Rendus, 156. pp. 1005-1008, March 31, 1918.)—Important corrections have to be introduced in pendulum observations to account for the influence of the support. The author discusses the correction formula of Peirce and Cellerier, $\alpha T = -\pi \sqrt{\lambda/g} \cdot 1/k \cdot Mgh/2\lambda^2$, where M is the mass of the pendulum, λ the length of the corresponding simple pendulum, h the distance between the centre of gravity and the axis of suspension, and k the statical coefficient of flexure. He points out that Plantamour has distinguished. VOL. XVI.—A.—1918.

guished two coefficients of flexure, viz., statical and dynamical, and since experiment has shown a great difference to exist between the two values there arises the question of which coefficient to adopt in the formula. Dessorges finds the statical flexure to be indicated by experiment. Now Peirce and Cellerier have introduced into the formula neither the mass of the support nor the possibility of phase between the two oscillating movements of support and pendulum. The author endeavours to establish that it is the coefficient of statical friction which should enter into the formula, and also that the necessary corrections depend neither on the mass of the support nor the internal friction which tends to stop the oscillations. The amplitude only is found to be affected by friction, and this diminishes slowly while remaining independent of the inertia mass of the support. H. H. Ho.

911. *Zone of Formation of Alternate Vortices behind an Obstacle.* H. BÉNARD. (Comptes Rendus, 156. pp. 1008–1006, March 31, 1918.)—The author has previously proved the formation of two parallel sets of gyration-centres, equidistant and alternate, on the surface of a liquid parted by a vertical prismatic object whose speed is uniform and parallel to its plane of symmetry. Also he has described a kinematographic method for demonstrating the laws of this periodicity. The present paper contains a very detailed description of the method accompanied by illustrations. In the latter a central dissymmetrical space is shown in the rear of the obstacle, constituting the vibration zone where the alternate vortices are formed. At two instants separated by a half-period the appearance of the zone is exactly symmetrical with regard to the plane of symmetry of the obstacle. The cases for speeds ranging from low to high are treated, and the conclusions drawn from each. H. H. Ho.

912. *Existence of a Superficial Viscosity in the Thin Transition Layer Separating one Liquid from another Contiguous Fluid.* J. BOUSSINESQ. (Comptes Rendus, 156. pp. 988–989, March 31, 1918.)—Where two liquids are in contact, or a liquid and a gas, there exists a thin superficial layer of separation which is not isotropic to the state of equilibrium like the neighbouring matter. Since a fluid is characterised by the property of never ceasing to return to its equality of constitution in every direction when deformed by external movement, and also when thermally disturbed, tends by an evolution of molecular groupings to equalise, more or less rapidly, the average distance of these apart, so will the same evolution take place in the transition layer separating two fluids to bring about complete isotropy. The author explains the enormous values per unit area of the superficial tension, by a general discussion of the tensions and pressures in the fluid. After considering the statical case, the author takes up the problem of fluids in a state of motion, pointing out that a certain interval of time is required, short for slightly viscous fluids and larger for others, before the internal configuration becomes that of final equilibrium. The nature of viscosity is thus introduced, and, after investigation, is applied to the case of the transition layer. The conclusion is drawn that the superficial tensions applied to a normal section of a film will always be tangential with respect to its plane, and that they will depend linearly upon the rates of deformation. It is necessary to know the rates of dilatation of two rectangular rows of molecules in a film and their rate of mutual sliding. The author then draws the conclusion that there will be two coefficients of superficial viscosity. Observations of capillarity have only been made by physicists under equilibrium conditions, and the author
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concludes that that is the reason why the idea of viscous forces has not been introduced. The author points out that these viscous forces are as necessary for the study of the superficial layer of a liquid as for the hydrodynamics of fluids in bulk.

H. H. Ho.

913. *Application of Formulæ for Superficial Viscosity to a Drop falling within a Fluid of Lower Density.* J. Boussinesq. (Comptes Rendus, 156. pp. 1085-1040, April 7, 1918.)—The results arrived at in a previous paper by the author [see preceding Abstract] are applied to the case of a drop of fluid (of spherical shape) falling slowly, with a motion which has become uniform, within a fluid at rest of less specific gravity. Suitable axes of co-ordinates are chosen and the drop is referred to these. Only the layer of separation is considered, which, owing to the slow rate of movement, may be assumed to possess a permanently spherical shape since the equations of motion remain linear owing to the fact that squares of velocities may be neglected. The various dynamic equations are then derived and the nature of each discussed.

H. H. Ho.

914. *Viscosity of Air.* L. Gilchrist. (Phys. Zeitschr. 14. pp. 160-165, Feb. 15, 1918. Phys. Rev. 1. Ser. 2. pp. 124-140, Feb., 1918.)—According to Millikan [Abstract No. 943 (1911)] the only limit to the accuracy with which the electronic charge can be determined is set by the difficulty of determining the absolute viscosity of air. The method of direct deflection used by the author reduces the error to 0.2 per cent. In this method an outer cylinder is kept in constant rotation, while an inner cylinder, attached to a bifilar suspension, measures the viscosity of the gas by a constant deflection. The mean value obtained for the viscosity at 20.2° is 1812.2 with a total probable error not exceeding 0.2 %. The presence of water-vapour up to 60 % of the saturation value at 20° has no effect on the viscosity, and at saturation the effect is an increase of not more than 0.8 %. E. E. F.

915. *Capillary Phenomena in Gases.* G. Reboul. (Comptes Rendus, 156. pp. 688-691, March 8, 1918.)—The chemical action of a gas on a solid is greatest at the points of max. curvature of the latter [see Abstract No. 729 (1918)]. To study the matter quantitatively, the author exposed a series of copper cylinders with diameters ranging from 0.28 to 1.5 mm. for 25 minutes to gas emitted by vulcanised rubber at a pressure of 1.6 mm., and estimated the thickness of the oxidised layer by the colour of the surface film. The results are the same as if there were an excess of pressure proportional to the curvature of the surface separating the solid from the gas. This leads to a formula similar to that given by Laplace for capillary force. This capillary action between solids and gases is paralleled by the electro-capillary force between mercury and gas discovered by the same author. E. E. F.

916. *Acrodynamics.* A. Lechner. (Phys. Zeitschr. 14. pp. 210-212, March 1, 1918.)—Determines both theoretically and experimentally the "phygoid" or trajectory of a flying model for the case when it moves in a liquid. The phygoid theory is directly applicable to liquids if the laws of resistance are the same as in air. The paths can either be circles or waves, according to the initial velocity and direction, and in the case of instability "tumbling" curves will be obtained. This was verified by means of flying models of thin sheet metal cut out in the rough outline of birds, and tipped with lead. These were released or projected in water. E. E. F.

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917. *Philosophical Aspects of Relativity.* R. D. Carmichael. (Phys. Rev. 1. Ser. 2. pp. 179-197, March, 1918.)—A clear *résumé* of the postulates of relativity and their logical consequences, together with the experimental basis upon which the theory rests; the whole being treated from the philosophical standpoint. Some extremely suggestive questions are proposed, such as: Is there any *absolute length* assignable to a given material body? Is there any absolute criterion of the simultaneity of events happening at different places? [See Abstracts Nos. 19 and 755 (1918).] E. H. B.

918. *Universal Measuring Apparatus for Photographic Survey and Micro-metric Measurement of Capillary Waves.* L. Grunmach. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 184-189, March 15, 1918.)—A full description of the apparatus, with photographs, is given. There are also three photographs of the waves obtained with mercury, water, and alcohol, and one showing the corresponding known distance between the points of the tuning-fork. A. E. G.

919. *Substitution of the Theodolite for the Perspective Nephoscope.* A. Lo Surdo. (N. Cimento, 5. Ser. 6. pp. 97-100, Feb., 1918.)—The author describes how the data previously shown [Abstract No. 570 (1918)] to be obtainable with the perspective nephoscope, can be more conveniently obtained by the use of a theodolite. W. H. St.

920. *Ponderomotive Forces in Relativity Theory.* M. Laue. (Phys. Zeitschr. 14. p. 210, March 1, 1918.)—Explains a discrepancy between his own and Planck's transformation formulæ for ponderomotor forces, worked out by Abraham's method [Abstract No. 1197 (1910)]. E. E. F.

921. *P. Appell's Equations and Continuous Media.* E. Guillaume. (Comptes Rendus, 156. pp. 875-879, March 17, 1918.)—Appell's dynamical equations are here extended to continuous media and also to electrons. E. H. B.

922. *Theory of the Phenomenon known as "Water-hammer."* L. Allievi. (Atti dell' Assoc. Elettr. Ital. 17. pp. 127-150, Feb. 28, 1918.)

923. *Ocean Waves, Sea-beaches, and Sandbanks.* V. Cornish. (Soc. Arts, Journ. 60. pp. 1105-1110, Nov. 1, and pp. 1121-1126, Nov. 8, 1912. Cantor Lectures.)—A table is included which gives the observed dimensions of waves as compared with those calculated by the general formula. The observed are in all cases somewhat lower than the calculated values. L. H. W.

924. *Errors of Meteorological Observations having a Psychological Origin.* G. Hellmann. (Preuss. Akad. Wiss. Berlin, Ber. 14. pp. 283-294, 1918.)—Of these some of the best known are mistakes of 5° and 10° in readings of temperature. Others arise from the practice of reading temperature to tenths of a degree, the thermometers being graduated either to fifths, halves, or whole degrees only. For thermometers divided to fifths of a degree the frequency of occurrence of the even tenths, coinciding with the graduation marks on the thermometer, is usually appreciably greater than that of the odd tenths, the reason being that the presence of the marks on consecutive even tenths favours a throw up or down to one of those values, or a reading falling between them, rather than a throw to the intervening odd tenth.

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The phenomenon is more pronounced at some stations than at others. For thermometers graduated in half degrees the frequency curves of readings of the different tenths of a degree fall in three classes, of which the first has maxima at 0 and 5 tenths, the second show minima at the same places, and the third has four maxima at 1, 4, 6, and 9 tenths. The corresponding frequency curves for thermometers graduated in whole degrees suggests that the observer really reads to quarters and not to tenths, there being 4 maxima. This type of error does not affect mean values. The results show that no great advantage results from dividing the degree into halves to assist the eye in estimating tenths, but division into fifths does result in more accurate observations such as are required for measurements of humidity. R. C.

925. *Standard Deviation, Asymmetry, and Correlation, with an Application to Variations of Pressure in Iceland, the Azores, and Europe.* W. Köppen. (Meteorolog. Zeitschr. 80. pp. 118-125, March, 1918.)—Some of the terms employed in the statistical methods which are in frequent use in this country, but appear to be almost unknown in German-speaking countries, are explained, and methods of computing correlation coefficients are described. An application to winter mean pressures over Iceland, the Azores, and Europe, from observations extending over the years 1865 to 1900 gives the following values for the correlation coefficients:—

Iceland—Azores	— 0.52	
Iceland—Vienna	— 0.42	
Vienna—Azores	+ 0.16	
Berlin—Vienna	+ 0.90	R. C.

926. *Antarctic Barometric Pressure.* G. C. Simpson. (Nature, 91. p. 185, April 10, 1918.)—The author calls attention to a very large rise of pressure which occurred in antarctic regions between Oct. and Nov., 1911, as shown by the records at the three stations Framheim (Norwegian winter quarters), Cape Evans, and Cape Adare. The mean pressure for Nov. exceeded that for Oct. by 0.87 in., 0.81 in., and 0.80 in. at the three stations respectively. This rise from one month to the next is considered to be unprecedented. J. S. DI.

927. *Rainfall over Long Periods.* A. E. Douglass. (Science, 87. p. 88, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—From a test extending over 48 years it is found that the radial thickness of the rings of the yellow pine of Northern Arizona gives a measure of the rainfall in the vicinity with an average accuracy of over 70 %. Variations of 21 years and 11.4 years were found. C. P. B.

928. *Rainfall measured along the Panama Canal.* (Meteorolog. Zeitschr. 80. p. 157, March, 1918. Report of Isthmian Canal Commission.)—A marked seasonal variation occurs, with minimum in Feb. or March (from 4 mm. to 92 mm. in a month), and double maximum in May-July (227 mm. to 497 mm.) and Oct.-Nov. (278 to 752 mm.). The rainfall along the Pacific coast is about half that measured on the Atlantic side, which varies from about 8800 to 4800 mm. in the year. At one station, so much as 28 mm. (0.9 in.) fell in 5 minutes. R. C.

929. *On the Coefficients and Exponent of the Radiation Equation, $K_{10} = cT_{10}^4$ in the Earth's Atmosphere.* F. H. Bigelow. (Amer. Journ. Sci. 85. pp. 254-VOL. XVI.—A.—1918.

266, March, 1918.)—A largely theoretical determination of the values of c and a in the above radiation equation, the necessary data being taken from certain published upper-air records in different parts of the world. The value of the exponent a is found to vary with latitude and height over a range of from 8.75 to 8.86. It is large at the surface and decreases with increase of height. J. S. Dr.

930. *Sky Radiation and the Isothermal Layer.* F. W. Very. (Science, 87. p. 87, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America. Amer. Journ. Sci. 85. pp. 869-888, April, 1918.)—Water-vapour is found at an altitude of 80 km. in the atmosphere, and as temperature inversion is intimately associated with excessive amounts of aqueous vapour it is possible that the region of permanent temperature inversion, the isothermal layer, may be due to this factor. Even in the coldest and driest weather, the sky temperature has never been found lower than that of the isothermal layer, which behaves like a nearly black body of approximate temperature 218° abs. C. P. B.

931. *Thermodynamics of the Earth's Non-adiabatic Atmosphere.* F. H. Bigelow. (Amer. Journ. Sci. 84. pp. 515-582, Dec., 1912.)

932. *Note on Atmospheric Radiation.* F. W. Very. (Amer. Journ. Sci. 84. pp. 588-588, Dec., 1912.)—The author discusses the radiation taking place in the different layers of the atmosphere with special reference to some of Bigelow's recent work on the subject [see preceding Abstract]. The paper is supplementary to this paper of Bigelow's. J. S. Dr.

933. *On the Origin of Falls of Dust in the Ocean West of the Sahara.* G. Hellmann. (Preuss. Akad. Wiss. Berlin, Ber. 14. pp. 272-282, 1918.)—An African origin of the red dust which frequently falls in the ocean between the Canary Isles and the Cape Verde Isles had been denied by Ehrenberg, who stated that there is no trade wind in the interior of Africa, and that there are no areas covered with red dust. The author shows that both statements are not in accord with observation. R. C.

934. *Temperatures of Subterranean Waters.* E. A. Martel. (Comptes Rendus, 166. pp. 741-742, March 8, 1918.)—On former occasions the author has made contributions to this subject and has drawn attention to the fact that there are seasonal variations of temperature much more considerable than had been previously supposed to be the case. The opinion that these underground waters have a very constant temperature corresponding to the mean annual temperature of the district where they are found, has been almost regarded as a meteorological law. Examination of the reports of subterranean water supplies obtained under the direction of Dabat, "directeur général des Eaux et Forêts," has furnished the material for completely exploding this antiquated idea. Thus in the Gironde a number of springs show variations of from 6° to 14° according to the time of year; in the Nord department these seasonal deviations run from 8° to 7° (6° or 8° to 12° or 18° C.), whilst in the districts of Douai and Cambrai many small springs not only vary in temperature but show a remarkable inferiority of 6° to 8° below the local mean annual temperature. Other remarkable results are quoted by the author. He arrives at the true meteorological and hygienic law that "the temperatures and delivery vary equally, and the more variable these are the

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more uncertain is their purity, for their filtering power is a function of their speed of transmission." This combined with the results of geological observation is of the greatest importance from the point of view of sources of drinkable water supply. The constancy of temperature exists only in the continuous sources from sand and similar material, artesian supplies at great depths slowly and regularly maintained. F. W. H.

935. *Solar Radiation during Eclipse, April 17, 1912.* W. Gorcynski. (Comptes Rendus de la Soc. Scientifique, Warsaw. Nature, 91. p. 87, March 20, 1918. Abstract.)—The diminution of the solar radiation began half an hour before the eclipse, and remained below the normal for the data for nearly the same time after. The drop in temperature was between 2° and 8° C. C. P. B.

936. *Radial Motion in Sun-spots.* C. E. St. John. (Science, 87. p. 28, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Three regions are indicated in the solar atmosphere surrounding spots with the following characteristics: (1) The upper chromosphere, motion inward, shown by the lines H and K of calcium, and H_α of hydrogen. (2) An intermediate region, shown by the D lines of sodium, b lines of magnesium, and the strong aluminium and iron lines, motion inward generally prevailing. (3) A lower region of outward motion, velocity increasing with lower levels. C. P. B.

937. *Pressure in the Solar Atmosphere.* C. E. St. John. (Science, 87. p. 28, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—An investigation involving the comparison of arc and solar spectra of iron is being carried out at the Mount Wilson Solar Observatory with the 150 ft. Tower telescope. The preliminary results show that the solar lines of iron classified in accordance with their displacement in the solar spectrum fall into the classes suggested by Gale and Adams in their study of pressure-shift under laboratory conditions, and indicate pressures in the solar atmosphere varying from 0.7 to 0.5 terrestrial atmospheres for the different groups. C. P. B.

938. *Atmospheric Transmission of Solar Radiation.* F. W. Very. (Science, 87. pp. 86-87, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America. Astrophys. Journ. 87. pp. 81-47, Jan., 1918.)—The coefficient of atmospheric transmission of solar radiations on a given day is variable because of the variation of atmospheric extinction with zenith distance, and because their absorbent quality changes in the middle of the day, especially if much moisture is present. A criterion of the accuracy attainable in different observations is illustrated in the discussion of results by Savélieff and Kimball. C. P. B.

939. *Irregularities in Atmospheric Refraction.* F. Schlesinger. (Science, 87. pp. 25-26, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—The investigation was suggested by the recent work of Nussl and Fric at Prague, who found irregularities in refraction having a period of about one minute, with considerable amplitude. A number of photographs were taken by Slocum at the Yerkes Observatory with the 40-in. refractor, VOL. XVI.—A.—1918.

showing the trails of the Pleiades stars. These trails were measured at Allegheny, and it was found that the irregular refraction was undoubtedly indicated, the results tending strongly to confirm the deductions of Nuss and Fric.

C. P. B.

940. *Absorbing Medium in Space.* E. S. King. (Science, 87, p. 82, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Evidence of the absorption of light in space is instanced, extending to 0.0877 mag. for the photographic rays, and 0.0184 mag. for the visual rays, while traversing the unit of distance, 82.6 light years. Other work extended the inquiry to a greater number of stars, and the former results were confirmed, suggesting the presence of some factor making the more distant stars appear redder.

C. P. B.

941. *Possible Lunar Changes.* P. Stolan. (L'Astronomie, Jan., 1918. Nature, 90, p. 629, Feb. 6, 1918. Abstract.)—A small hill to the north of the line joining the lunar features Thebit and Birt has been suspected of undergoing changes of size and shape.

C. P. B.

942. *Scale of the Durchmusterung.* E. C. Pickering. (Science, 87, p. 26, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—In *Harvard Annals*, 28, the deviations, from the photometric scales, of the magnitudes 9.0 and brighter are discussed. Volumes 70 and 74 include a similar study of the fainter stars, and of those in the Cordoba Durchmusterung. The deviations of the Cape Durchmusterung magnitudes from the photometric magnitudes are reduced one-half by grouping stars on the same plate and applying a correction for the class of spectrum.

C. P. B.

943. *Stellar Spectra with Objective Prism.* E. C. Pickering. (Amer. Philosoph. Soc., Proc. 51, pp. 564-567, Oct.-Nov., 1912.)—The principal advantages of the objective-prism method for stellar spectrum photography are (1) the small loss of light; (2) the large number of stars which may be photographed simultaneously; (3) that it is not necessary to follow, as when photographing star charts. With the Harvard 8-in. doublet as many as three or four hundred spectra are often obtained on a single plate, including all stars of the ninth magnitude and brighter, in a region ten degrees square. A comparison spectrum cannot be used with an objective prism, and it is therefore difficult to obtain absolute wave-lengths, which are needed to determine the motion of stars in the line of sight. Various plans have been devised to overcome these drawbacks. The latest investigation undertaken at the Harvard College Observatory is the classification of 100,000 stellar spectra taken with the 8-in. doublets.

C. P. B.

944. *Systematic Motions of the Stars.* B. Boss. (Science, 87, p. 27, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Analysis of the distribution of stars shows the prevalence of B-type stars in the galactic plane, a similar grouping for the A-type stars, while the stars with more advanced spectra appear to be distributed more at random. Considered in relation with the star motions this suggests that a state of approximately random motions must eventually prevail throughout the universe.

C. P. B.

945. *Magnitude Scale of Polar Sequence.* F. H. Seares. (Science, 87, pp. 84-85, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. VOL. XVI.—A.—1918.

of America.)—With the object of determining absolute star magnitudes a series of magnitude determinations have been made of the stars in the polar sequence. The mean deviations of groups of stars from results obtained at Mount Wilson and Harvard are tabulated, showing satisfactory agreement down to magnitude 15.5; beyond this limit there is a divergence as yet unexplained. C. P. B.

946. Relation between Spectrum and Colour Index of Stars. J. A. Parkhurst. (Science, 87. pp. 80–81, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Revised data from a catalogue of magnitudes and spectra of northern stars furnishes material for a curve showing the relation between spectrum and colour index. The range in magnitudes of the stars used is between 4 and 9. Plotting the colour index as abscissæ and the spectral class as ordinates, a straight line is found to fit the points better than any simple curve. C. P. B.

947. Orbits of 44 Eclipsing Binaries. H. Shapley. (Science, 87. pp. 29–30, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Using the methods developed by Russell, orbits have been computed for all eclipsing variable stars for which there exists reliable photometric data. In the majority of cases circular elements satisfactorily represent the observations. C. P. B.

948. New Eclipsing Variable Stars. J. Stebbins. (Science, 87. p. 26, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—It seems probable that a considerable number of the short-period spectroscopic binaries are eclipsing variable stars, and several of these have been investigated with the selenium photometer. α Virginis and α Coronæ Borealis are such variables, and β Scorpii is suspected. C. P. B.

949. Spectroscopic Binary η Camelopardalis. O. J. Lee. (Science, 87. p. 88, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America. Astrophys. Journ. 87. pp. 1–24, Jan., 1918.)—Frost and Adams announced the dual nature of this system in 1904, basing the result on measures of broad lines. From observations covering 8000 days, the form of the velocity curve is incompatible with a simple two-body system, and a certain form of calcium envelope has been assumed. The period is 7.9957 days. C. P. B.

950. Orbit of Binary System ϵ Hydra A.B. R. G. Aitken. (Science, 87. pp. 87–88, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—This close double star, discovered by Schiaparelli in 1888, may be analysed for orbital elements both visually and spectroscopically. The micrometer measures, give a period of 15.8 years. Other elements are given. C. P. B.

951. Orbit of λ Tauri. F. Schlesinger. (Science, 87. p. 84, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Eighty-nine spectrograms of this bright Algol-variable have been secured with the Mellon spectrograph of the Allegheny Observatory. Elements of the orbit calculated from the photographic reductions are appended. The period is 8.9529 days. C. P. B.

952. *Spectrographic Observations of Algol.* F. Schlesinger. (Science, 87. p. 84, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—A series of spectrograms have been made with the Mellon spectrograph during the last six years, 886 plates being secured. The long-period oscillation in the radial velocities, first announced by Bépolsky in 1906, has been confirmed, and this is accompanied by a similar oscillation in the times of light minimum. C. P. B.

953. *Chromospheric Lines in Spectrum of ϕ Persei.* P. W. Merrill. (Lick Observatory Bull. No. 224. Nature, 91. pp. 94-95, March 27, 1918. Abstract.)—From a survey of B-stars having bright hydrogen lines the author concludes that the spectrum of ϕ Persei shows evidence of the presence of chromospheric radiations. The lines of helium, magnesium, and sodium show anomalies compared with the spectrum of the solar chromosphere. C. P. B.

954. *Spectrographic Observations of ϕ Persei.* F. C. Jordan. (Science, 87. p. 84, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—This has been known to be a bright-line star since 1889, and a period of variability given as 126.5 days. Preliminary measurements give a velocity curve different for the bright hydrogen lines and for the absorption lines, but not such a curve as would be due to a secondary body. C. P. B.

955. *Spectrum of Pleiades Nebula.* Slipher. (Lowell Observatory, Bull. No. 55. Nature, 91. p. 94, March 27, 1918. Abstract.)—From an exposure of 21 hours on the spectrum of the Pleiades nebula the author obtained a record showing continuous spectrum crossed by strong hydrogen lines and faint helium lines. No traces of the gaseous nebula lines could be detected. It is suggested that the nebula shines by reflected light from Merope. C. P. B.

956. *Magnitudes of Stars in Coma Berenices.* Hnatek. (Astronom. Nachr. No. 4629. Nature, 90. p. 710, Feb. 27, 1918. Abstract.)—From five plates taken with a 4-in. Anastigmat portrait lens, a series of photographic magnitudes of 104 stars in the cluster Coma Berenices have been determined. The comparisons with results of other observers show evidence that the differences vary with magnitude and spectral class. C. P. B.

957. *Spectra of Nova Geminorum (1912).* S. B. Barrett. (Amer. Philosoph. Soc., Proc. 51. p. 568, Oct.-Nov., 1912.)—Various notes are given showing the changes in the spectrum of Nova Geminorum (1912) as photographed at the Yerkes Observatory, including details of radial velocity, breadth of bands, etc. C. P. B.

958. *Proper Motions of Faint Stars.* G. C. Comstock. (Science, 87. pp. 82-88, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Results are presented applying to 250 stars fainter than the tenth magnitude on the Harvard scale. C. P. B.

959. *Stellar Magnitudes, Parallaxes and Radial Velocities.* G. Jäger. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1629-1658, Oct., 1912.)—A discussion is given of the observations used in formulating the relations between the stellar groups of varying magnitude, parallax, and radial velocity, a series of tables showing the results for about 180 stars. C. P. B.

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LIGHT.

960. Autocollimating Mounting for Concave Grating. H. C. Richards. (Amer. Philosoph. Soc., Proc. 51. pp. 554-568, Oct.-Nov., 1912.)—An autocollimating mounting is described whereby several of the disadvantages introduced in previous methods are more or less successfully eliminated. The chief of these consists in the provision of means whereby the necessity of separately adjusting the distance of the grating and inclination of the camera for each new angle of incidence is done away with. This is most ingeniously managed by the adoption of a "lazy tongs" connection between the grating and camera-slit, the total length when open being equal to the radius of curvature of the grating. The first and last link on one side are fixed normal to the grating and plate respectively. The camera is mounted on its platform on either side of the slit or preferably just above it, and may be adjusted so as to bring the plate into coincidence with the focal circle. If the slit be made double the apparatus may be used as a monochromatic illuminator of high purity. As everything is supported on one track the apparatus may be made quite rigid, and takes up much less space than the other forms of mounting for the concave grating. It is also very simple to fit the instrument with a light-proof cover, so that it may be used in an undarkened room. The most important disadvantage of the autocollimating method is that the spectra are not normal; the deviation, however, is small, and may readily be compensated.

C. P. B.

961. Plane Grating Spectrograph for Stellar Work. J. S. Plaskett. (Science, 87. pp. 81-82, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—Preliminary tests have been made with a Littrow grating spectrograph of $87\frac{1}{4}$ in. focal length, giving a dispersion of $17.5 \text{ \AA. per mm. at } H_{\gamma}$. Comparisons are made of the efficiency of the instrument compared with that of a prismatic spectrograph of similar power, the grating instrument being distinctly superior towards the violet and ultra-violet.

C. P. B.

962. New Form of Spectrograph Collimator. P. Fox. (Science, 87. pp. 26-27, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—In using a spectrograph in conjunction with large relative apertures such as those of large reflectors, a form of collimator is proposed consisting essentially of a small Cassegrain reflector. The light coming through the slit falls on the perforated concave mirror, which then throws the light upon a small perforated convex mirror, mounted immediately behind the slit. This second mirror is of such curvature that it throws a parallel beam through the perforation of the first mirror, on the prisms. The ratio of perforation to aperture in both cases is equal to the ratio of aperture of the telescope objective to the diagonal mirror, and the aperture of the convex mirror is equal to the perforation of the concave, so that there is no loss of light.

C. P. B.

963. 24-inch Objective of the Sproul Telescope. J. A. Miller and R. W. Mariott. (Science, 87. p. 29, Jan. 8, 1918. Paper read before the Astronom. and Astrophys. Soc. of America.)—This large objective was completed by

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J. A. Brashear and Co. in Dec., 1911, for the Sproul Observatory of Swarthmore College. Extra-focal exposures on Capella were made through a screen containing 44 circular holes 88 mm. diam. and the results investigated according to Hartmann's method. Other tests were made on Arcturus with a different screen. The measures showed the presence of slight astigmatism, but the characteristic 0.274 shows the objective to be an excellent one.

C. P. B.

964. *The Optophone*. E. E. Fournier d'Albe. (Phys. Zeitschr. 18. pp. 942-948, Oct. 1, 1912.)—Two selenium bridges are balanced against two adjustable carbon resistances in a Wheatstone-bridge arrangement. A fine adjustment of manganin wire serves to make the balance so accurate that a high-resistance telephone makes no sound when the "galvanometer current" is sent through it and interrupted by a clockwork arrangement giving about 10 breaks per sec. Then, when one of the bridges is exposed to light, while the other is dark, a sound is heard in the telephone. The two Se bridges are mounted side by side in a camera-like box containing the clockwork and a 4-volt battery, and lights and luminous objects are perceived by means of the ear, the max. effect being produced by the strongest contrasts. E. E. F.

965. *Refractive Index of Selenium*. W. S. Gripenberg. (Phys. Zeitschr. 14. pp. 128-124, Feb. 1, 1918.)—When melted Se is pressed between plate glass, sheets from 20 to 250 $\mu\mu$ in thickness may be obtained [Abstract No. 920 (1912)]. In spite of rapid cooling, small circular portions, less than 0.2 mm. in diam. become crystalline. They show much greater absorption of light than the amorphous Se, and have a higher refractive index. The interference colours are of a higher order in the crystalline Se than in the amorphous Se. They show that the refractive index is from 1.16 to 1.27 times greater. This gives a refractive index 8.5 for sodium light, or the highest refractive index known among elementary substances. This result was confirmed by making a film of Se on glass by kathode disintegration and crystallising one-half of it. The crystallised half showed narrower interference rings than the amorphous half, the diameters being as 4 to 5.

E. E. F.

966. *Temperature Change of Refractive Index for Water*. F. A. Osborn. (Phys. Rev. 1. Ser. 2. pp. 198-210, March, 1918.)—The method here adopted is that first used by Reimerdes (Inaug. Dissertation, Jena, 1896). The change of refractive index is determined by the shift of interference fringes in a fused quartz system (which is represented in a figure), an Abbe-Pulfrich interferometer being employed (Zeitschr. für Instrumentenkunde, p. 261, 1898). The final results are shown in a graph and expressed by the equation $\mu_p/dt = -10^{-7} \times (118.78 + 41.4184t - 0.02876t^2 - 0.0048757t^3)$, which represents the experimental determination to about one unit in the seventh decimal place. [See Abstract No. 52 (1918).] E. H. B.

967. *Torque by Beam of Light in Oblique Refraction through Glass measured Dynamically*. G. Barlow. (Roy. Soc., Proc. Ser. A. 88. pp. 100-102, Feb. 24, 1918.)—In a previous research the torque was measured statically [see Abstract No. 1677 (1912)]. It is here measured dynamically by its effect in changing the period of oscillation of the suspended glass cube. The mean value of the change in period derived from eight experiments is 0.162 sec. The theoretical value for the same case is calculated to be 0.158 sec., thus showing a satisfactory agreement. E. H. B.

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968. Selective Dispersion of Mercury Vapour. R. W. Wood. (Phys. Zeitschr. 14. pp. 191-195, March 1, 1918. Phil. Mag. 25. pp. 488-489, April, 1918.)—Since mercury vapour can be kept in transparent vessels, and its density is accurately known, it is suitable for the study of selective dispersion in non-luminous absorbing gases. The end-plates of the vessel used by the author were of white fluorspar, since the double refraction of quartz would have introduced disturbances. The metallic deposit used was a cathode deposit of gold, as silver does not deposit well on fluorspar. The temperature was maintained constant by means of a hot-air bath worked by an aspirator. A low density of vapour was used, and an interferometer method of observing the dispersion. Only one absorption band was studied, that of wave-length 2536, which has the advantage of falling in the midst of a group of strong iron lines. On forming the vapour, the system of fringes passing along the length of the spectrum is displaced in the iron lines in different directions and by various amounts. The temperature ranged from 84° to 58° C., and the displacements did not exceed the width of one fringe. It is clear, however, that the refractive index of the vapour near the absorption band does not increase to an extent proportional to the density of the vapour. It is therefore very doubtful whether this absorption line is due to the normal mercury molecule. The dispersing molecule may either be an atomic complex or an ionised molecule, and probably such molecules are rare in comparison with normal molecules. In any case, the percentage of molecules in this condition decreases as the vapour density increases. Not all the molecules present take part either in absorption or dispersion. E. E. F.

969. Liquid Mixtures especially suitable for observing Christiansen's Phenomenon. F. Bodroux. (Comptes Rendus, 156. pp. 772-774, March 10, 1918.)—Under suitable experimental conditions, when two liquids with slight mutual solubility and with nearly equal refractive indices are shaken together vigorously so that an emulsion is formed, the mixture becomes clear at a certain temperature and brightly illuminated objects appear vividly coloured when viewed through it. This phenomenon was observed by Christiansen with suspensions of finely-divided solids in liquids of nearly the same refractivities. The use of white light generally gives a white colouration which, when the temperature is slightly raised, passes successively through orange, red, violet, and blue, the liquid ultimately becoming turbid. On cooling the liquid again, these colours reappear in the inverse order. Two solutions which show this phenomenon well are: (1) 15 c.cm. of ethyl acetate and 10 gm. of water poured into 50 gm. of saturated aqueous sodium chloride solution; this mixture is extremely sensitive to heat, the warmth of the hand sufficing to change the colour shown. (2) To a solution of 25 gm. of sodium bromide in 85 gm. of water propyl alcohol is added drop by drop until the shaken mixture shows the desired colouration.

With certain mixtures, rise of temperature causes the appearance of the different colourations in the opposite order to that given above; such are formed when ether and amyl alcohol are added to aqueous saccharose or glycerol solutions of suitable refractivity. T. H. P.

970. The Photographic Plate. IX. The Latent Image. V. W. D. Bancroft. (Journ. Phys. Chem. 17. pp. 98-158, Feb., 1918.)—The general conclusions drawn from a detailed consideration of the literature concerning the latent image are as follows:—The latent image must be a reduction product, since the action of light can be duplicated by that of a suitable reducing agent. It

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cannot be free metallic silver or a single definite subhalide or a mixture of several such compounds, but must be regarded as a phase of continuously varying composition, probably of silver bromide with adsorbed metallic silver. The latent image is identical with the photohalides except as regards colour, and photoregression is due chiefly to the recombination of halogen with the latent image, apparently by adsorption. This adsorption theory furnishes an explanation of all the phenomena of solarisation. The latent image which yields a negative under normal development consists of silver bromide with an excess of about 0.002–0.1 per cent. of silver; with higher excesses of silver, positives are obtained on development. The second negative is not due to metallic silver. The latent images produced by heat, acids, pressure, etc., are unlike that produced by light, and do not necessarily involve a change in the ratio of silver to bromine, but are due to removal of gelatine, etc. [See Abstract No. 484 (1912).] T. H. P.

971. Direct Photographic Positives. G. A. Perley and A. Leighton. (Journ. Phys. Chem. 17. pp. 285–248, March, 1918.)—The production of a positive by the Waterhouse process is most easily influenced by alterations of the conditions governing the reaction. The variables considered in this preliminary paper are: time of exposure, temperature of development, time of development, size of plate, amounts of sodium carbonate, hydroquinone, thiocarbamide, sodium sulphite and water. The emulsion and actinic value of the light are kept constant. It is found that with a given concentration the temperature cannot be varied more than 1 deg. C. The quantity of developer, best expressed in plate surface units, governs the resultant positive. An excess of any constituent which favours an increase in the development of the latent image yields a partial negative (or a masked positive); an insufficient amount produces uniform development and a resultant fog. An excess of thiocarbamide acts as a solvent for the emulsion; an insufficiency does not visibly affect the thin negative resulting from normal development. A suitable restrainer for yellow fog and thin negatives would yield great improvements. The contrast and clearness of the final deposit depend much upon the emulsion on the plate. The sources of dissatisfaction with the present positive are: the bluish colour of the deposit, the necessity of a preliminary appearance of a thin negative, and the appearance by reflected light of a yellowish fog. Other experiments are in progress.

A. E. G.

972. Remarkable Case of Optical Resonance. L. Dunoyer. (Comptes Rendus, 156. pp. 1067–1070, April 7, 1918.)—The phenomenon of diffuse surface resonance, noticed by Wood in the case of mercury vapour [see Abstract No. 1182 (1912)], may be readily observed with pure sodium vapour. A small flask, carefully freed from gas and containing a little sodium, is arranged in the hot gases of a chimney above a Bunsen burner. In front of the flask is placed the flame of a Méker burner fed with air charged with very dilute pulverised sodium chloride solution, the flame being surrounded by a chimney with a sharp-edged aperture. From any point outside the bundle of rays reflected regularly by the wall of the flask the image of the aperture is invisible so long as the flask remains cold. When the temperature of the flask exceeds 100° the trace of the exciting rays traversing the flask appears. The resonant luminosity increases gradually, and, just below 200°, it is no longer limited exactly by the path followed by the exciting rays, but becomes highly diffused and seems to fill the entire flask. As the tempera-

ture continues to rise this diffuse light diminishes more and more, as also does the penetration of the exciting light into the vapour. At about 250° the region of resonance has a depth of only 5-6 mm., and at 300° its thickness is no longer perceptible, so that, from whatever point the front face of the flask is viewed, so long as the visual ray does not traverse the vapour, the image of the source is seen as clearly as if it were formed on a sheet of white paper adherent to the inner wall of the flask. It is highly probable that, if the sodium vapour were rendered sufficiently dense, regular reflection would be observed, but attack of the glass by the vapour prevents this. In this connection it would be interesting to study the law of distribution of the light diffused in different directions, to ascertain if this law approaches that of regular reflection as the temperature rises. Observed through the flask filled with hot vapour the flame does not show appreciable diminution in brilliancy, and it would therefore seem probable that the useful exciting light is limited to a very narrow region in the centre of the D-rays. This is in apparent connection with the observation that the diffuse surface resonance image increases but slightly in brilliancy when the luminous source is augmented considerably in sodium and therefore in brilliancy.

T. H. P.

973. Absorption Coefficient in Electric Field. H. J. van der Bijl and G. Sziwey. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 151-155, March 15, 1918.)—To explain the double refraction of an isotropic substance in an electric field theories have been put forward by Langevin, by Larmor, and by W. Voigt, that by the latter requiring a change in the absorption coefficient of the substance for light by the electric field. This point has been experimentally tested with the result that the change in absorption, if present, must be less than $\frac{1}{4}$ per cent. in CS_2 for an electric field of the order of 20,000 volts per cm.

E. H. B.

974. Emission and Absorption by Luminous Flames. R. Ladenburg. (Phys. Zeitschr. 14. pp. 195-198, March 1, 1918.)—From investigations of the optical properties of strongly luminous hydrogen, the author concluded that the ratio of emission to absorption is different at different wave-lengths of the widened red hydrogen line H_{α} [Abstract No. 487 (1911)]. This apparent contradiction of Kirchhoff's law is attributed by Brothorus [Abstract No. 1868 (1912)] to a lack of homogeneity in the luminous gas. This explanation is refuted by some further experiments described by the author, in which the light from a hydrogen discharge is sent through a Wratten colour filter transmitting only the line H_{α} , and is then photographed and studied photometrically. Besides, layers of hydrogen a few mm. thick have not sufficient absorption to allow them to produce reversal phenomena. A possible explanation is that several types of emission-centres go to make up the line, and that the latter really consists of a line proper and a continuous luminous background.

E. E. F.

975. Interference with Wedge-shaped Plates. L. Janicki. (Ann. d. Physik, 40. 8. pp. 498-499, March 20, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—A continuation of previous work [see Abstracts Nos. 55 and 65 (1918)]. Good agreement is found between measurements of the sharp interference bands obtained with two semi-silvered wedge-shaped plates of small angle, and the theory of von der Pahlen [Abstract No. 889 (1918)].

A. W.

976. Analysis of Slightly Elliptical Light Vibrations. E. Perucca. (Accad. Sci. Torino, Atti, 48. No. 8. pp. 181-181, 1912-1918.)—A full account of an experimental study of the half-shade polariser and compensator of Brace [Abstract No. 1018 (1904)], from which it is concluded that this is much more sensitive than any other method, having a probable error of less than 1'. W. H. St.

977. Relation between Temperature and Rotation of Active Substances, for Light of all Refrangibilities. T. S. Patterson. (Chem. Soc., Journ. 108. pp. 145-177, Feb., 1918.)—Evidence is given that the rotatory power of a very large number of substances after increasing with rise of temperature passes through a maximum value and then diminishes again. Maxima are also observed when rotatory power is plotted against wave-length in cases of "anomalous" rotatory dispersion. It is suggested that both results may be interpreted by supposing that rotatory power is a periodic function of temperature, wave-length, etc. A modified sine-formula is suggested as indicating the general nature of the function. T. M. L.

978. Magnesium Spectrum. A. Nacken. (Zeitschr. wiss. Phot. 12. pp. 54-64, March, 1918.)—Measurements of the arc and spark lines of Mg were made with a Rowland concave grating, 6.84 m. radius and 20,000 lines to the inch. The results, from $\lambda 6494$ to $\lambda 4282$ in terms of the international normal and from $\lambda 4282$ onwards in terms of the normal of Buisson and Fabry, are tabulated and compared with the wave-length measurements of other experimenters. [See also Abstracts Nos. 245 and 1282 (1910).] A. W.

979. Magnetic Rotation of Polarised Light by Liquid Nitrogen and Oxygen. J. Chaudier. (Comptes Rendus, 156. pp. 1008-1010, March 31, 1918.)—Previous experiments on the magnetic rotation of polarised light by liquefied gases have only been undertaken in the case of readily liquefiable ones, e.g. sulphuretted hydrogen, nitrous oxide, methyl chloride. The author extends the study to gases difficultly liquefiable, such as nitrogen and oxygen which can now be obtained pure commercially. The classical apparatus of Verdet and Becquerel was employed, slightly modified in certain details to admit of the use of Dewar vacuum vessels and also to improve the mode of reading. After each determination corrections were necessary on account of the influence of the cylindrical glass vessel. When employing yellow sodium light the author finds that the magnetic rotation of the plane of polarisation is proportional to the intensity of the field and the thickness traversed when the active liquids are oxygen and nitrogen; also, the sense of the rotation is positive, similar to water. The rotatory powers ρ^D for nitrogen and ρ^D_O for oxygen at 18° C. are:—

$$\begin{aligned}\rho^D_N &= 0.00415 = 0.415 \times 10^{-2}. \\ \rho^D_O &= 0.00782 = 0.782 \times 10^{-2}.\end{aligned}$$

The magnetic rotatory power of oxygen is therefore approximately double that of nitrogen. For carbon disulphide at the same temperature,

$$\rho^D_{CS_2} = 0.042 = 4.2 \times 10^{-2}.$$

The author gives a table of the rotatory magnetic dispersions of liquid oxygen and nitrogen for light of different wave-lengths, drawing the following conclusions:—Nitrogen obeys the inverse square law of the wave-length, and

only disperses for vibrations of short wave-length; its rotatory magnetic dispersion is near that of methyl chloride and less than carbon disulphide. Oxygen possesses a feeble rotatory magnetic dispersion, does not obey the inverse square law, and disperses in a contrary sense to carbon disulphide. The results are analogous to those obtained for gaseous oxygen and nitrogen.

H. H. Ho.

980. *Absorption of Ultra-violet Light by Ozone and Limit of Solar Spectrum.* C. Fabry and H. Buisson. (Comptes Rendus, 156. pp. 782-785, March 10, 1918. Journ. de Physique, 8. Ser. 5. pp. 196-206, March, 1918.)—The limitation of the solar spectrum, a little below the wave-length 8000, has been attributed to absorption by ozone. This hypothesis is only based on the existence of a strong ozone absorption band in the ultra-violet. To confirm it, numerical values are necessary relating to atmospheric absorption and to absorption by ozone. These determinations have been undertaken by the authors. The results for ozone show that maximum absorption is found near $\lambda 2550$. In this region the absorption is exceptionally great: a thickness of pure ozone of only 25μ will reduce the intensity of the incident light by one-half. Between the wave-lengths 2900 and 8800 the absorption varies rapidly. Measurements of atmospheric absorption made in 1912 showed that for $\lambda 8000$, the proportion of transmitted light is of the order of 1/100. To produce this absorption it would be necessary for the atmosphere to contain a quantity of ozone equivalent to a layer of pure ozone 5 mm. thick. If this were uniformly distributed, the proportion would be 0.6 cm.^3 per m.^3 of air, a quantity much greater than that given by chemical analysis. The most probable hypothesis is that ozone exists almost entirely in the upper layers of the atmosphere.

A. W.

981. *Wave-lengths of Krypton.* H. Buisson and C. Fabry. (Comptes Rendus, 156. pp. 945-947, March 25, 1918.)—The authors have previously shown [Abstract No. 1190 (1912)] that the rare gases of the atmosphere give extremely fine lines, especially when the discharge tubes are cooled in liquid air. For many purposes it seems to be advantageous to use these lines in preference to those of cadmium. A krypton tube requires no heating; the two lines can be separated without dispersive apparatus, using absorbing media: chloride of didymium for the yellow line, eosine for the green. The two lines are in a region of the spectrum very favourable to visual observations, and are from this point of view superior to the Cd red line. A little distance from the green line is a very faint line ($\lambda = 5568$), which can be separated by dispersion, but which is so faint it gives no trouble if neglected. The authors have utilised their measurements of the order of interference obtained with the Cd and Kr lines to determine the wave-lengths of the green and yellow Kr lines; the values found for the wave-lengths of Kr in air at normal pressure and at 15°C. , using as standard the wave-length of the red Cd line given by Benoît, Fabry, and Perot, are 5570.2908 and 5870.9172, with possible errors of a few units in the last place.

A. W.

982. *Spectrum of Helium in Canal Rays.* J. Stark, A. Fischer, and H. Kirschbaum. (Ann. d. Physik, 40. 8. pp. 499-541, March 20, 1918.)—A lengthy paper dealing with the spectrum of the singly and doubly charged helium atomions in canal rays. It was found that the max. velocity in the displaced line for He canal rays in He mixed with an electronegative gas is considerably greater than for He canal rays in pure He. In pure He the

displaced line bears to the stationary line a ratio very much smaller than in He mixed with an electronegative gas ; or, in other words, admixture of an electronegative gas increases, in the spectrum of He canal rays, the ratio of the displaced line to the stationary line. The He line $\lambda 4472$ is found to have for carriers the positive singly-charged He atomions, while the carriers for the line $\lambda 4888$ are doubly-charged atomions. More generally, the authors conclude that the principal series and the two subordinate series of doublets have for carriers the positive singly-charged He atomion ; the principal series and the two subordinate series of simple lines of He have for carriers the positive doubly-charged He atomions. Runge and Paschen associate the first set of these series with "helium," the second set with "parhelium." [See Abstracts Nos. 1069 (1907), 658 (1911), 601 (1918).] A. W.

983. *Mutual Influence of Spectrum Lines of Same System in the Magnetic Field.* G. Wendt. (Ann. d. Physik, 40. 8. pp. 607-608, March 20, 1918.)—In view of the publications of F. Paschen and E. Back, and also of W. Voigt, the author draws attention to his results and remarks on the same subject [see Abstract No. 867 (1912)]. Also he has found that in the case of some very bright lines the shading-off is discontinuous, i.e. may be resolved into fine lines. As the separation of these lines decreases with decreasing wavelength he concludes that it is a case of interference fringes. J. M.

984. *Spectrum of Carbon Arc at Low Pressures.* M. La Rosa. (Ann. d. Physik, 40. 8. pp. 542-550, March 20, 1918.)—Describes the phenomena of the carbon arc spectrum at low pressures in greater detail than in the author's previous paper [Abstract No. 1862 (1912). See also Abstract No. 2055 (1909).] A. W.

985. *Series Systems in the Spectra of Zinc, Cadmium, and Mercury.* F. Paschen. (Ann. d. Physik, 40. 8. pp. 602-605, March 20, 1918.)—A continuation of previous work [see Abstracts Nos. 1486 (1911) and 419 (1918)]. Fresh evidence is brought forward in support of the author's combination series formulæ. [See also Abstract No. 598 (1918).] A. W.

986. *Electron Theory of Phosphorescence.* C. A. Butman. (Phys. Rev. 1. Ser. 2. pp. 154-160, Feb., 1918.)—According to the author's theory of phosphorescence, the incident light causes the electrons in the light-emitting atom of the complex phosphorescent molecule to be brought to a critical energy-content causing the selective emissions characteristic of the substance. At the same time the light causes electrons to be ejected from the photoelectric atom, return of these electrons to the molecule by collision causing the luminosity to continue. In the case of the alkaline earth sulphides, this theory regards the photoelectric atom as sulphur, whereas Lenard's theory indicates it to be the heavy metal. Evidence in support of the author's view is discussed. [See also Abstract No. 1878 (1912).] T. H. P.

987. *Luminescence of Phosphorus Vapour.* H. Schmidt. (Phys. Zeitschr. 14. pp. 120-128, Feb. 1, 1918.)—Saturated solutions of phosphorus in almond oil and phosphorus emulsions in water were used. Various gases were pumped through the liquids, and the bubbles ascending through them showed a luminescence, which, however, ceased as soon as all the traces of oxygen had been displaced. As soon as this occurred, the gases issuing from the orifice of the bottle showed luminescence on getting into contact with the atmo-

sphere. All this was observed in the case of CO_2 , H , and N_2O . Coal-gas did not show the same phenomena; it stopped the luminescence and the formation of fog. Oxygen, on the other hand, may be saturated with phosphorus vapour and show little luminescence until on arriving in the air its partial pressure decreases and an intense glow is produced. The ionisation of air by phosphorus fumes were studied, but the results were inconclusive as regards the process of ionisation. E. E. F.

988. Theory of Luminescence. E. Pringsheim. (Phys. Zeitschr. 14. pp. 129-181, Feb. 16, 1918.)—Considering the similarity between the dispersion electrons and Planck's resonators it is probable that many considerations applicable to the latter also apply to radiant energy from gases, whether that be temperature radiation or luminescence. In vacuum tubes, and in spark and arc discharges, we probably have to do with luminescence due to electrical processes. It is remarkable that here also the relative intensity of the shorter waves increases with the degree of excitation. This is intelligible on the theory of quanta, since with a greater incident energy the cases become more frequent in which a resonator of high frequency receives energy sufficient to lead to the emission of a quantum. Assuming that the emissive and absorptive powers are independent of the density of radiation, the author traces an analogy between luminescent bodies and black bodies on the basis of the quanta theory. He shows that the ratio of emission to absorption for all wave-lengths at which there is emission (owing to the presence of dispersion electrons) changes with the wave-length from one spectrum line to another in the same way as the emissive power of the black body does at the "specific temperature." The latter (Bauer's "emission temperature") is for a given wave-length that temperature at which the emissive power of the black body equals the ratio of emission to absorption in the radiating body. Then the difference between this specific temperature and the true temperature of the radiator gives a measure of the deviation from Kirchhoff's law and for the degree of luminescence. E. E. F.

989. Diffraction of Short Electromagnetic Waves by a Crystal. W. L. Bragg. (Cambridge Phil. Soc., Proc. 17. 1. pp. 48-57, Feb. 14, 1918.—A mathematical discussion of the experimental results of Friedrich, Knipping, and Laue on interference phenomena with Röntgen rays [K. Bayer Akad. München, Ber., June, 1912; also Abstract No. 266 (1918)]. E. H. B.

990. Reflection of X-rays. H. Moseley and C. G. Darwin. (Nature, 90. p. 594, Jan. 30, 1918.)—Studying the grazing reflection of X-rays from mica, the authors find that the reflected beam resembles ordinary X-rays. It ionises air and helium and produces a soft radiation when it strikes metals. The variation of its ionisation in air with pressure is also similar. Effects are obtained as great as 1 or 2 per cent. of the primary beam. The same absorption of the reflected beam is produced by aluminium, whether the rays pass through it before or after reflection. This indicates that the character of the rays is unaltered by reflection. The amount of reflection increases, however, with the hardness. The energy of the X-rays appears to show the contrary properties of extension over a wave-front and concentration in a point. E. E. F.

991. Reflection of X-rays. W. H. Bragg. (Nature, 90. p. 219, Oct. 24, 1912.)—Referring to the observations of Friedrich, Knipping, and Laue
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[Abstract No. 266 (1918)] the author finds that when the crystal (zincblende) is placed so that the incident rays are parallel to an edge of the cube in the crystal the positions of the spots are to be found by the following simple rule. The atoms being assumed to be arranged in rectangular fashion, any direction which joins an atom to a neighbour at a distance na from it, where a is the distance from the atom to the nearest neighbours and n is a whole number, is a direction which a deflected (or secondary) pencil will take, and it will in doing so form one of the spots. In other words, we have to seek for all the cases in which the sum of three squares is also a square, and we then recover the positions of all the spots on the diagram. For example, secondary pencils take the directions (2, 8, 6) (4, 1, 8), and so on. In a few cases the sum of the squares is one short of a perfect square, e.g. (5, 7, 11), but in no case is it on the greater side; and there is at least one direction (2, 5, 14) which ought by the rule to be on the diagram and is not. Otherwise the rule is quite successful.

L. H. W.

992. *Photographic Effect of X-rays and X-ray Spectra.* C. G. Barkla and G. H. Martyn. (Phil. Mag. 25. pp. 296-300, Feb., 1918.)—It is well known that the absorption properties of any material for X-rays depend largely on the nature of the characteristic X-rays of the elements contained in the material. In the present paper this question has been studied for the silver and bromine atoms contained in the grains in the emulsion of a photographic plate. A photographic plate was exposed to the characteristic X-radiations of series K from various elements. The exposure was made for a period sufficient for the various radiations to produce the same total ionisation in air in an electroscope. After development of the plates it was found that the radiations had not produced equal photographic effects, that for Ce, for example, being about 2.7 times that for Cu. The variations of the photographic effects with the atomic weight of the radiator were, however, somewhat anomalous, being approximately constant for elements of lower atomic weight than Br, then increasing rapidly and becoming again approximately constant for elements with atomic weights between those of Br and Ag. With further increase of atomic weight of radiator another rapid increase in photographic effect was observed until the effect became again constant up to the material of highest atomic weight investigated, i.e. Ce. The results are exhibited by plotting the photographic effect determined as above against the "wave-length" of the characteristic radiation employed, the "wave-length" being calculated by equating Planck's quantum ($h\nu$) to the energy of the maximum-velocity electrons set free from a plate by the particular characteristic radiation (i.e. $v = \text{at. wt.} \times 10^8$). The general results show that when the absorption in AgBr relative to that in air increases either through the Br or through the Ag, the increase in photographic effect is approximately proportional to the increase in absorption.

E. M.

993. *Reflection of X-rays.* C. G. Barkla and G. H. Martyn. (Nature, 90. p. 647, Feb. 18, 1918. Phys. Soc., Proc. 25. pp. 206-214; Discussion, pp. 214-215, April 15, 1918.)—By allowing a divergent pencil of Röntgen radiation to fall at nearly grazing incidence on one of the sets of cleavage planes of a crystal of rock-salt, and observing the intensity of the reflected pencil by a photographic plate, the authors find a series of well-marked and equal-spaced maxima in positions corresponding to equal increments of $\cos \theta$, where θ is the angle of incidence of the radiation on the cleavage planes. In the directly transmitted beam there is no indication of variation of

intensity with angle of incidence. There appears to be a series of X-ray spectra of different orders due to agreement in phase of waves from successive layers of molecules. Calculating on this assumption the authors get a wavelength of the order of magnitude in agreement with that calculated from the velocity of ejection of electrons by a substance exposed to this particular radiation. E. E. F.

994. *Interference Bands from Röntgen Rays.* E. Hupka and W. Steinhaus. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 162-168, March 15, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—The authors find that if Röntgen rays fall at almost grazing incidence on mica or rock-salt the reflected image when photographed is divided into two parts by a clear median space. Further, of the two reflected images photographed, that which is farther from the transmitted image shows parallel bands perpendicular to the plane of reflection. The paper has one figure showing the X-ray tube, the chamber containing the oblique crystal and the photographic plate. Another figure is a reproduction of the photograph on which six dark bands are clearly visible. (Ibid. pp. 164-166, March 15, 1918.)—The authors now assume that the reflections of the X-rays occur at the various molecular layers, and thus give rise to a number of virtual images of the actual source on the antikathode. Hence, reckoning the interference in the usual way from these sources, the experimental data lead to the value of the wavelength for these Röntgen rays $\lambda = 1.8 \times 10^{-10}$ cm. Walter and Pohl from direct diffraction experiments found an upper limit of $\lambda = 1.2 \times 10^{-9}$ cm. W. Wien at first found from energy measurements—

$$\lambda = (1.15 \text{ to } 2.8) \times 10^{-10} \text{ cm.}$$

More recently Wien has found from Planck's *Wirkungsquantum* the value $\lambda = 6.5 \times 10^{-9}$ cm. E. H. B.

995. *Reflection of X-rays.* H. B. Keene. (Nature, 91. p. 111, April 8, 1918.)—In continuation of the experiments of W. L. Bragg [Abstract No. 604 (1918)] the author has investigated the reflection of X-rays by mica. A narrow pencil of X-rays was allowed to fall on a sheet of mica at an angle of incidence of 70° , a photographic plate being placed perpendicular to the plane of the mica. On the incident side of the mica five beams were shown on the developed photographic plate, that obeying the ordinary laws of reflection being the most obvious. On the "transmitted" side of the mica there were not less than thirty distinct beams, those of greatest photographic intensity being those which had suffered least deviation. Besides giving rise to numerous pencils in definite directions, the mica sheet exhibits the ordinary incidence and emergent scattering, which cause a general fog of the plate. Similar effects were obtained using rock-salt and galena. E. M.

996. *Röntgen Radiation from Kathode Particles traversing a Gas.* R. Whiddington. (Cambridge Phil. Soc., Proc. 17. 1. pp. 144-146, Feb. 14, 1918.)—The experiments described show that when very slow kathode particles traverse a gas at low pressure, Röntgen rays are emitted all along their path. Kathode rays from a lime kathode were projected along a tube provided with a side-tube. In the side-tube an Al electrode was arranged inside an earthed evacuated cylinder provided with a very thin window facing the kathode stream. The Al electrode was found to acquire a positive charge due to the emission of negative particles under the influence of the

Röntgen rays falling on it, further support of this view being obtained by applying a metal stop or a transverse magnetic field in front of the window. The velocity of the cathode particles emitted from the electrode due to the incident Röntgen radiation was found to be not far different from the velocity of those streaming out of the lime cathode. E. M.

997. Production of Fluorescent Röntgen Radiation. J. C. Chapman. (Phil. Mag. 25. pp. 859-870, March, 1918.)—Bragg and Porter [Abstract No. 1496 (1911)] have suggested that not only is ionisation by X-rays an indirect phenomenon due to β -rays, but that, in addition, the fluorescent or characteristic X-rays themselves are possibly due also to action of the β -rays. To settle this point, as to whether the characteristic X-rays are produced directly or indirectly, experiments were made so that in the case of one radiator the β -corpuscles were certainly absorbed in the radiating substance, while in the case of another radiator the corpuscles lost their energy in a substance in which it is impossible to produce measurable secondary characteristic radiation. The two radiators were constructed of thin sheets of gold and paper, so as to have the same mass of each substance, but arranged differently in the two cases. The intensity of the characteristic gold radiation excited in each radiator was the same, although on Bragg's hypothesis a ratio of 1.9 should have been shown. The experiments are evidence, therefore, that the atom from which the electron is ejected is the seat of the production of the characteristic radiation. E. M.

998. Secondary Radiation produced by α -Particles. B. Bianu. (Comptes Rendus, 156. pp. 785-788, March 10, 1918.)—In the present paper evidence is given showing that when α -particles of polonium fall on a metal plate a negatively-charged ionising radiation is emitted. The polonium is placed in a shallow dish facing the metal plate, and the ionisation current measured at different pressures beyond a wire gauze placed underneath the dish. A magnetic field almost suppresses the ionisation, the small residue being probably due to α -particles diffusely reflected from the plate. The value of the velocity is deduced to be 1.8×10^{-9} cm. per sec., and the product of the range (mm. of air) and pressure (mm. of Hg) about 100. The amount of radiation is practically independent of the nature of the metal on which the α -particles fall. E. M.

999. Occlusion of Products of Radium. Costanzo. (Comptes Rendus, 156. pp. 126-127, Jan. 18, 1918. Extract.)—Curie's experiments led to the conclusion that with metals there is no appreciable occlusion of RaEm, but he had only used Al, Cu, Pb, Bi, Pt, and Ag. The author has used Pd, and has found that this metal has similar properties for the disintegration products of Ra to those it possesses for hydrogen. Circular discs of Pd were employed 2 cm. in diam., and respectively 1 mm., 0.5 mm., 0.1 mm. thick. After drying and washing with ether, they were introduced into an enclosure containing the radio-active material together with three corresponding discs of india-rubber and three of brass for comparison. Examination of the discs after being in the enclosure for 48 hours gave the following results:—(1) Brass follows the laws established by Curie for induced radio-activity. (2) Palladium shows the phenomenon of occlusion of the disintegration products of Ra almost to the same degree as indiarubber for sufficiently thin plates. (8) The thickness of the active plates appears to have, in the phenomenon of occlusion, a small influence which is not as yet sufficiently defined, but which

is, however, appreciable. (4) For thick plates, and under the conditions of experiment, the activity observed on withdrawing the plate from the enclosure, is at first much greater with Pd than with indiarubber. The author suggests replacing the metallic wires used for studying induced radio-activity, especially in the atmosphere, by Pd wires. The phenomena of occlusion may also be employed for estimating the radium-content of the material in the enclosure, for the quantity of the Ra products absorbed by a plate of given surface and thickness is, for a sufficiently long exposure and under identical conditions of experiment, proportional to the quantity of Ra in the enclosure.

A. W.

1000. *Relations between Radio-active Elements emitting α -Rays.* R. Swinne. (Phys. Zeitschr. 14. pp. 142-145, Feb. 15, 1918.)—There is a quantitative relation between the atomic constants, the decay constant, and the initial velocity of the α -particles expelled by radio-active elements which can be expressed by different formulæ giving nearly the same results [see Abstracts Nos. 168, 696 (1912)]. The author finds that the difference between the initial velocity of an α -radiator of one family and that of the corresponding member of another family is nearly constant for these two families. Thus the radio-active disintegration forming chemically analogous elements in the various radio-active series takes place by steps which are not the same in different series, but differ by nearly constant quantities. A new relation discovered by the author is that the decay constants of the analogous α -radiators of different families stand in a nearly constant ratio to each other.

E. E. F.

1001. *Variation in Activity of Uranium Nitrate.* M. La Rosa. (Giornale di Sci. naturali ed economiche, 29. Palermo, 1912. N. Cimento, 5. Ser. 6. pp. 78-82, Jan., 1918.)—The activity of uranium nitrate is found to be diminished by the radiations from an electric arc, by warming to 100°, and by drying the surrounding air, these effects being attributed by the hygroscopic nature of the salt and to the solubility of its emanation.

W. H. St.

HEAT.

1002. *Thermal Radiation from Hot Gases.* W. T. David. (Phil. Mag. 25. pp. 256-270, Feb., 1918.)—Gives first a brief review and criticism of the experimental work which has been done on the emission of thermal radiation from hot gases. Probable theories of the origin of radiation from gases are also dealt with. The question as to whether a hot gas can emit radiation in virtue of its temperature alone is discussed, and though further experimental work is necessary before the question can be definitely settled, it seems highly probable that the low-frequency vibrations of CO₂ and water-vapour giving rise to infra-red radiation are excited by molecular collisions. Paschen's experiments on the emission from hot CO₂ and water-vapour have been looked upon as affording conclusive evidence that molecular collisions excite the low-frequency intra-molecular vibrations of these gases, but the author shows that in these experiments the absorption of radiation from the hot tube walls might possibly be responsible for exciting these radiations. Experiments are suggested to settle this question. In experiments by Hopkinson and the author [Abstract No. 1708 (1911)], a greater max. pressure and a slower rate of cooling of a gaseous mixture after explosion was found when the walls of the explosion vessel were reflecting than when they were black. Also the radiation emitted from a certain thickness of the gaseous mixture is greater when the walls of the vessel are reflecting than when black. The most natural interpretation of these experiments is that the radiation reflected back into the gaseous mixture from the polished walls goes primarily to increase the energy in the vibratory degrees of freedom of the molecules, and that this excess is then partitioned off into the translational and rotational degrees during molecular collisions. A. W.

1003. *Resonance with the Longest Thermal Waves.* R. W. Wood. (Phys. Zeitschr. 14. pp. 189-191, March 1, 1918. Phil. Mag. 25. pp. 440-448, April, 1918.)—Describes experiments with waves of the order of 0.1 mm., obtained from an incandescent gas-burner by the method of focus isolation. Various metallic resonators suitable for the study of these long waves are described. One type consists of powdered copper dusted on to quartz plates. The deposits are nearly opaque to visible light, but transmit long heat-waves perfectly. The same amount of metal, deposited as a coherent sheet, would be quite opaque to long waves. Finely-divided deposits are obtained in the shape of a "dew" deposited on quartz plates by mercury vapour, the diam. of the droplets ranging from 0.01 to 0.08 mm., according to the length of exposure to the vapour. The degree of opacity of each plate is compared with that of a quartz plate by measuring the amount of energy transmitted when the wave-length is 1 μ , the measuring instrument being a radio-micrometer. For this wave-length each droplet acts simply on an opaque obstacle. For the longest thermal waves, the transparency is perfect so long as the diam. of the droplets does not exceed 0.1 of the wave-length. When the diam. is about $\frac{1}{4}$ of the wave-length, the transparency for the longest heat-waves is not much greater than for the short ones. With still greater diameters, the transparency for both kinds of waves is about the same. In no case is the transparency of the resonating plate less for the long waves than for the

short. This means that each drop only intercepts whatever energy actually falls upon it, and withdraws nothing from the neighbouring regions. On the other hand, when a sheet of silver deposited on quartz is split up into small rectangles by means of a dividing engine cutting the portions as small as 0.1 of a wave-length, the sheet is as opaque as before, nor is its conductivity changed.

E. E. F.

1004. *The Constants of Spectral Radiation of a Uniformly Heated Enclosure.* W. W. Coblentz. (Washington Acad. Sci., Journ. 8. pp. 177-180, April 4, 1918.)—The temperature scale used in the investigation for temperatures above 1400° C. is the optical scale, which is obtained by adding to the thermoelectric temperatures certain values which are the mean of several groups of thermo-couples. For temperatures above 1400° C. an abrupt rise in the value of the constant c in Wien's formula was noticed [Abstracts Nos. 80, 487, and 1187 (1907)]; but this was found to be due to taking too large correction factors for reduction to the optical scale. The mean value of the constant c from the two years' work is $c = 14,466 \pm 4$, while $A = 2911 \pm 1$. Computing similarly the values obtained by Lummer and Pringsheim and by Paschen the mean values of c would be $14,466 \pm 40$ and $14,458 \pm 25$ respectively. Warburg gives recently a mean value $c = 14,874 \pm 4$. The mean value from the four sets of observations may be taken as $c = 14,420$ mikron deg. and $a = 2905$ mikron deg.

The following is the summary of the results of the series of observations:—

Series.	Number of Energy Curves.	Mean Value c .	Remarks.
1911 I	26	14,469	Unpainted Marquardt porcelain radiator
1912 I	7	14,468	Radiator as in 1911. New optical adjustments
II	14	14,482	Radiator painted with chromium oxide
III	7	14,466	New unpainted Marquardt radiator
IV	9	14,446	Radiator painted with the oxides of cobalt and chromium
V	14	14,476	Radiator repainted; new optical adjustments
VI	8	14,461	New thermo-couples; radiator as in preceding series
VII	9	14,486	New water-cooled shutter; rest of apparatus as in preceding series

J. J. S.

1005. *Spectro-photometric Comparison of the Emissivity of Solid and Liquid Copper at High Temperature with that of a Full Radiator.* C. M. Stubbs. (Roy. Soc., Proc. Ser. A. 88. pp. 195-205, March 81, 1918.)—In a previous paper [Abstract No. 442 (1918)] the author and Prideaux gave the results of a spectro-photometric comparison of the emissivity of solid and liquid gold at high temperatures with that of a full radiator or "black body." For solid

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gold, the curve for relative emissivity against wave-length was shown to be similar to, but not identical with, that for absorptivity at low temperatures obtained by other workers. Whether the difference was due to a difference in the structure of the surfaces examined or to a real temperature-coefficient of the absorptivity remained an open question. The author now describes a similar investigation of the emissivity of copper and silver. The method used and apparatus employed were only modified in few details from those of the former paper. The "black body" used was of the Lummer-Kurlbaum type [Abstract No. 1871 (1901)] and its peculiarities receive detailed description. Temperature was measured by a thermo-couple, while the apparatus was so arranged that the radiating chamber could by actual trial be made to coincide with the region of uniform temperature. The heating was by means of two windings of "nichrome" No. 22 resistance wire, on independent circuits, insulated from each other and from the iron tube by several layers of asbestos paper; the outer one was, as suggested by Waidner and Burgess, wound more closely at the ends than in the middle. The advantages obtained are evenness of temperature distribution, and automatic lining of the walls of the chamber, on heating, with iron-oxide, which possesses a good degree of "blackness." Both the copper and silver were kept in a reducing atmosphere to avoid surface oxidation of the former and dissolution of oxygen in the latter, which, if incurred, would result in a considerable lowering of the freezing-point with consequent uncertainty in temperature measurement and possibly also a change in emissivity. Experiments with necessary precautions and attendant difficulties are then described in detail. As in the case of gold, the emissivity of copper is found to be discontinuous at the melting-point although the difference between that of the solid and liquid is less marked. Previous measurements on the radiation from liquid copper have been made by Burgess, and the wide disparity between his values and the author's is discussed. As an explanation Burgess's results are said to be in error owing to lack of monochromatism of the coloured glasses used in his pyrometer, and to far less favourable experimental conditions. Previous results of Hagen and Rubens, Miner, and Tool then receive critical consideration. The conclusion is unavoidable that the absorptivity in the visible spectrum of a polished copper surface changes on heating, a change only suggested in the previous paper for gold. The "relative emissivity" of liquid silver was found to be remarkably low throughout, but seemed to be somewhat greater than the corresponding values of the absorptivity of solid silver at ordinary temperatures. "Black-body" temperatures of solid and liquid copper and of liquid silver at the respective melting-points are calculated. H. H. HO.

1006. Mode of Combustion of Carbon. T. F. E. Rhead and R. V. Wheeler. (Chem. Soc., Journ. 108. pp. 461-489, March, 1918.)—In continuation of their previous work, showing that carbon dioxide and monoxide are produced together when carbon is burned [see Abstract No. 1227 (1912)], the authors have made experiments to account for this simultaneous production of the two oxides. It is found that, at all temperatures up to 900° and probably above, carbon pertinaciously retains oxygen, which can be removed, not by exhaustion alone, but only by exhaustion and increased temperature together. When rapidly released in this manner the oxygen appears as a mixture of the two oxides of carbon, the proportion between the two depending on the temperature at which the carbon has been heated during oxygen fixation. It is shown that no physical explanation alone can account for this fixation of oxygen, which is probably the outcome of a.

physico-chemical attraction between oxygen and carbon, since it seems hardly possible to assign any definite formula to the complex formed which varies in composition, whilst no isolation of the complex can be effected by physical means. Decomposition of the complex by heat produces CO_2 and CO , in definite proportions at a given temperature. Nearly these same proportions are found when a rapid current of air at a given temperature is passed over carbon previously saturated with oxygen at the same temperature.

T. H. P.

1007. *Latent Heat of Vaporisation of Metals.* E. van Aubel. (Comptes Rendus, 156. pp. 456-457, Feb. 10, 1918.)—The author verifies Trouton's law that the molecular heat of vaporisation of a liquid, divided by the temperature (Kelvin) of ebullition at atmospheric pressure is a constant which is approximately 20. The following figures are obtained from Landolt-Börnstein's tables:—

Metal.	Temperature (Kelvin) of Ebullition.	Atomic Weight.	Latent Heat of Vaporization.	Trouton's Constant.
Mercury	680°	200.0	68.6	20.20
Cadmium	1051°	112.4	181.0	19.86
Zinc	1191°	65.4	865.8	20.08
Bismuth	1706°	208.0	161.6	19.66
Magnesium.....	—	24.8	1700.0	—

Assuming that Trouton's constant is 20 for magnesium, we deduce that its melting-point is 1792°. Ditte gives 1100°, Greenwood 1120°, and v. Wartenberg 2200°, but Grüneisen from theoretical considerations computed the boiling-point to be 1810° Kelvin, which is in good agreement with the result found by Trouton's law.

A. R.

1008. *Latent Heats of Vaporisation and Maximum Pressures.* A. Leduc. (Comptes Rendus, 156. pp. 225-227, Jan. 20, 1918.)—The determination of the heats of vaporisation of liquids at their boiling-points is comparatively easy, but the results obtained by different investigators at other temperatures show considerable divergence. Variable numbers have also been obtained for the vapour pressures of liquids at different temperatures.

Making use of the value of the specific volume of the saturated vapour, μ' , derived from his own equation of state, $MF\mu' = RT\phi$, the author has calculated the heats of vaporisation of water at 100°, 180°, and 160°; of ether at 10°, 80°, and 50°; and of benzene at 60°, 80°, and 100°, by means of Clapeyron's formula, $L = T/J \cdot (\mu' - \mu) \cdot dF/dT$, where F represents the vapour pressure. The calculated results differ from the observed values, especially with ether and benzene, and the author suggests the desirability of fresh measurements on the pure substances and of converting the temperatures used to the thermodynamic scale.

T. H. P.

1009. *Vapour Pressures of the Alkali Metals.* A. Kröner. (Ann. d. Physik, 40. 3. pp. 488-492, March 20, 1918.)—The method used in determining the vapour pressures of the alkali metals consisted in measuring the pressure of an indifferent gas, nitrogen, in the apparatus at a constant temperature, introducing the metal, and measuring the increase in pressure

caused thereby; the determinations were carried out at constant pressure and not at constant volume. The vapour pressures of caesium and potassium were determined for temperatures varying between 249.5° and 855.5° C. for the former metal, and 249.5° and 896.6° for the latter metal. The rule of Ramsay and Young was then applied in order to calculate the boiling-points of these and the other alkali metals.

T. S. P.

1010. *Determination of the Heats of Solution of Metals by means of a Vacuum Flask Calorimeter.* E. E. Somermeyer. (Phys. Rev. 1. Ser. 2. pp. 141-153, Feb., 1918.)—The adiabatic calorimeter used by Richards and Burgess [Amer. Chem. Soc. 22. p. 481, 1900] for the purpose of eliminating radiation entirely is costly and slow, so that, for reactions occupying as long as 15 or 80 minutes, the author suggests the use of a Dewar flask, with which the correction for radiation and conduction is reduced to a very small amount. The errors accompanying the use of such a flask are discussed, and the amounts of heat developed in various reactions have been measured in order to ascertain the accuracy of the method. Three determinations of the heat of fusion of ice gave the values, 79.98, 79.88, and 79.89, the mean 79.92 being in almost exact agreement with Smith's value [see Abstract No. 2966 (1904)]. Measurements of the amounts of heat liberated when various metals were dissolved in acids also gave satisfactory results.

T. H. P.

1011. *Energy Absorbed in Photochemical Reaction.* V. Henri and R. Wurmser. (Comptes Rendus, 156. pp. 1012-1015, March 31, 1918.)—Experiments were made in two ways, and from them and data as to the eye three estimates are obtained as to the energy required per molecule in a photochemical reaction. The values are: 6.4×10^{-14} , 5.5×10^{-14} , and 8.96×10^{-14} . The last named is for the eye if only one molecule is decomposed in one-hundredth of a square millimetre, which is inadmissible. Hence, in each case, the energy in question is less than the energy quantum of Einstein.

E. H. B.

1012. *New Thermodynamic Consequence of the Quanta Hypothesis.* M. Póányi. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 156-161, March 15, 1918.)—Points out a complete analogy between the states of zero absolute temperature and infinite pressure; in such case the specific heat, the radiation, the entropy content, and entropy differences are zero.

E. H. B.

1013. *Quanta Theory of Gases and Liquids.* H. Tetrode. (Phys. Zeitschr. 14. pp. 212-215, March 1, 1918.)—If Nernst's supposition is correct that gases, like solids, have zero specific heat at the absolute zero of temperature, it becomes possible to treat gases by the methods applicable to condensed systems, and no "chemical constant" need be specially introduced. Since a gas at the absolute zero cannot occupy a finite space in a stable condition, it must be regarded as a supersaturated vapour. This artifice is as legitimate as Maxwell's derivation of the vapour pressure of a liquid from the equation of condition. The error introduced in the entropy of a gm.-mol. by the deviation of such a vapour from the ideal gas laws can be minimised by making the ordinary volume of the gas so large that it only reaches or exceeds the saturation pressure at a very low temperature. The author applies the method of Debye [Abstract No. 446 (1918)], but deals with cubical instead of spherical volume elements, thus greatly simplifying the reasoning, and approximating

it to that familiar from the theory of radiation. The terms in Debye's formulæ which refer to transverse waves are omitted in the case of liquids and gases. The formulæ obtained show that at the higher pressures the quanta effects should become appreciable even at the ordinary temperatures, and should be superimposed upon the van der Waals' corrections. But the author admits that the results are only provisional. E. E. F.

1014. *Theory of Solids*. S. Ratnowsky. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 75-91, Feb. 15, 1918.)—Discusses the difference between Grüneisen's equation of condition for solid bodies [Abstract No. 268 (1918)] and his own [Abstract No. 1544 (1912)] in which the Planck-Einstein function appears, thus making it possible to deduce the effect of temperature. The discrepancies between the theoretical and experimental coefficients of expansion (diamond, etc.), induced the author to frame a new equation of condition, based, like Debye's formula for specific heat, upon a plurality of frequencies instead of one characteristic frequency. E. E. F.

1015. *Dissipation of Energy*. L. Décombe. (Journ. de Physique, 8. Ser. 5. pp. 89-101, Feb., 1918.)—The author discusses the question of the dissipation of energy from the much-debated standpoint as to whether it is capable of mechanical interpretation, *i.e.*, whether it may be explained on the same principles as those forming the basis of rational mechanics. Such a reduction appears to be incompatible with the classical definitions of fundamental mechanical principles, and this investigation takes the form of finding whether the latter express the essentials of the mechanical principles or whether they are really nothing more than a particular modification. The principle of inertia as also that of equality of action and reaction are not considered, since neither possesses a truly fundamental character, but only the principle of the independence of simultaneous effects and especially of the independence of the state of rest or motion. The former expresses the independent effect of each force, the latter that the effect of a force does not depend on the actual motion of the moving point to which it is applied. From the latter may be deduced that a force is never a function of the speed, but in general depends on the position of the point, *i.e.* on its co-ordinates and not on their differentials with respect to time.

The dissipation of energy, however, is manifested in all phenomena where forces of dynamic friction or viscosity are present in any degree whatever, such forces being termed passive resistances and found to be functions of the speed. The irreversible evolution of heat, inseparable from the work done by passive resistances, constitutes essentially the phenomenon of dissipation. Here appears an apparent contradiction to the principle of the independence of rest or motion, but before accepting such a conclusion as final there is need, first, to distinguish between the principle itself and the definition by which it is usually construed, and then to find whether a more general form would give a more satisfactory result.

The author begins by a critical examination of the fundamental mechanical definition of the resultant of two vectors, where the co-ordinates of the moving point are continuous functions of the time admitting first and second differentials which are also continuous functions. He notes that the accepted definition is not capable of direct verification, since our means of observation do not permit us to follow the ultimate details of motion of a material point and to discern the very small discontinuities by which it may be affected. If, then, the motion of the point considered be

supposed to undergo very small and very rapid variations, as would be the case with an irregular disturbance of small amplitude (e.g. the Brownian movement), it is no longer permissible to consider two neighbouring positions on the trajectory, while there is need to distinguish between the concealed movement represented by the irregular motion and its movement as represented by a displacement (apparently continuous) which may be considered as the graph of mean positions. This idea of distinction between the two movements is not original, having been proposed by Helmholtz in his researches on the second principle of thermodynamics. The author elaborately investigates the subject vectorially from the above standpoint, and substitutes for the classical definition an equivalent one, arrived at by considering three consecutive positions of the moving point separated by the same infinitesimal time-interval. The continuity is first supposed perfect, and an analytical expression for the revised definition is obtained. The case when the motion is made up of infinitesimal discontinuities is then developed, and the conclusion drawn that the motion is due, not only to the given forces, $X(x, y, z)$, $Y(x, y, z)$, $Z(x, y, z)$, which are functions of the co-ordinates alone, but also to forces which are functions of the speeds, dx/dt , dy/dt , dz/dt . Under these assumptions the supposed forces, far from contradicting the principle of the independence of the state of rest or motion, are a necessary consequence of it.

The author does not suggest that his considerations give a complete solution of the problem of the dissipation of energy, but that they point out means by which difficulties may receive adequate treatment. He then considers the special case of a central force for repulsion and attraction, taking as example an electron directed towards a position of equilibrium by a central force proportional to the distance.

H. H. HO.

1016. *Molecular Agitation at Absolute Zero.* A. Einstein and O. Stern, (Ann. d. Physik, 40. 8. pp. 551-560, March 20, 1918.)—This paper presents an argument for the assumption that there is some agitation and energy of the molecules even at the absolute zero. The results of Eucken's work on the specific heat of hydrogen make the existence of the energy $h\nu/2$ at absolute zero probable. The acceptance of this value of the energy at absolute zero opens a way to derive Planck's radiation formula without the auxiliary assumptions of any discontinuities whatever. It may be noted that the *second* form of Planck's expression for the energy of a resonator runs—

$$E = h\nu/(e^{h\nu/kT} - 1) + h\nu/2.$$

This gives the energy $h\nu/2$ at zero and approaches the value kT at high temperatures. Planck's first form omitted the second term on the right.

E. H. B.

1017. *Kinetic Theory and Irreversibility.* E. Borel. (Journ. de Physique, 8. Ser. 5. pp. 189-196, March, 1918.)—Without pretending to attain a mechanical explanation of irreversibility, the author in the present paper endeavours to point out how such a solution of the problem should be sought.

E. H. B.

1018. *Black-body Radiation and Quanta Theory.* J. de Boissoudy. (Comptes Rendus, 156. pp. 766-768, March 10, 1918.)—Discusses the form of the probability function in the Poincaré theory of Planck's quanta hypothesis of complete radiation [see Abstract No. 841 (1912)]. [Errata, Ibid. p. 1198, April 14, 1918.]

E. H. B.

SOUND.

1019. *Air-currents and Auditorium Acoustics.* F. R. Watson. (Eng. Record, 67. pp. 265-268, March 8, 1918.)—Theory and experiment are here applied to elucidate the possible influence of air-currents on the acoustical properties of the auditoriums in which, for heating or ventilation, they are made to occur. The subject was previously attacked by W. W. Jacques (Phil. Mag. 5. vol. 7, p. 111, 1879), who found that the ventilating system of the Baltimore Academy of Music was so arranged that it had a very pronounced action on the acoustics. According to the survey of Jacques, by thistle balls and anemometer, the movement of the air in the above theatre was as follows. The whole supply of fresh air was admitted at the back of the stage, was there warmed, then crossed the stage horizontally *above* the speakers, actors, or musicians, passed through the proscenium, and then, somewhat diagonally toward the roof, across the auditorium in one grand volume and with gentle motion so as to almost entirely prevent the formation of minor air-currents. It was exhausted partially by an outlet in the roof, and partly by numerous registers in the ceilings of the galleries. From this central outlet and from the large flues of the registers, the air passed into the ventilating tower over the great chandelier, whose heat supplied part of the motive power of the circulation. The acoustics of this auditorium were considered excellent. The weakest voice was audible to every seat in the house; sounds such as a sigh, a kiss, or even the simulated breathing of the somnambulist, might be heard in the most distant parts; and all musical effects were exactly appreciated. All singers and speakers agreed in describing the facility with which the voice was used on this stage.

The present author's theoretical examination of the above case, based on the work of Rayleigh and of Tyndall, shows that the portions of sound passing *steeply* upwards and forwards from the stage would be almost entirely transmitted into the warmer air-current overhead. On the other hand, those parts of the sound that rise but slightly in their forward motion, strike very obliquely the boundary between the cold and the warm air, and are thereat almost entirely reflected. These conclusions theoretically reached were experimentally corroborated in part by the timing of the residual sounds or resonance from an organ-pipe in a room with and without burners lit.

As to minor factors affecting the relative amounts of transmission and reflection, it is found that the more or less moisture and local slow motions of the warming and ventilating currents will have only a negligible effect. The magnitude of the reflection at the boundary of cold and warm air depends chiefly on density ratio, and therefore upon temperature difference. Haphazard currents of air or those intervening between the speaker and the audience are detrimental, and should be avoided.

E. H. B.

1020. *Phonographic Investigations of Consonants.* L. Réthi. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1595-1609, Oct., 1912. Communication from the Phonogramm-Archiv-Kommission.)—This work forms part of an endeavour to make phonograph records legible, it being desired if possible to establish the wave-forms for each letter of the phonetic alphabet. In the research the experimental arrangement of F. Hauser was adopted, both glass and ebonite diaphragms being used. A number of consonants and semi-vowels were dealt with, the following being represented in photographic reproductions:—H, L, M, N, R, P, T, K, F, Ss, Sch, Ch (forward and backward).

E. H. B.

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ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1021. *Equilibrium between Oscillators, Free Electrons, and Radiant Heat.* M. Planck. (Preuss Akad. Wiss. Berlin, Ber. 18. pp. 850-868, 1918.)—A mathematical and physical treatment of the subject on the basis of the author's quantum hypothesis of the second form in which the *emission only is discontinuous*; the absorption of radiation and the free propagation of electromagnetic waves *in vacuo* follow Maxwell's equations. After an introduction and statement of the physical assumptions, expressions are obtained for (i) the energy of the vibrations of the oscillators, (ii) the energy of free electromagnetic radiation, (iii) the energy of free electrons. Equilibrium conditions and irreversible phenomena are dealt with at the close. [See Abstract No. 1016 (1912).] E. H. B.

1022. *Electromagnetics and Relativity.* S. J. Barnett. (Science, 87. pp. 560-561, April 11, 1918.)—A defence of the author's position against the opinion raised by A. L. Kimball. [See Abstract No. 210 (1918).] E. H. B.

1023. *Atmospheric Potential.* E. MacLennan. (Nature, 90. pp. 647-648, Feb. 18, 1918.)—Calls attention to the paradox that in spite of a potential gradient of 100 volts per metre there is no current in a vertical conductor in the earth's electrostatic field. E. E. F.

1024. *Horned Lightning Conductors and Related Phenomena.* H. Greinacher. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 128-188, March 15, 1918.)—The usual explanation given of the action of horned lightning conductors is, that at the narrowest part the lighted arc is forced upwards mainly by the action of hot air, and, it attains such a length on reaching the horns that it is extinguished. This explanation is unsatisfactory. One is now given in which the action is considered as mainly electromagnetic, and experiments are described to show that this is the true explanation of the phenomenon. Experiments are also described in which the discharge is produced by weak currents, and photographs are given illustrating the results obtained at low pressures. A. E. G.

1025. *Atmospheric Electrification during Dust-storms.* V. H. Jackson. (Nature, 91. p. 218, May 1, 1918.)—It is found that at Patna in North India westerly winds, which occur in the daytime from the middle of March till June and raise a great deal of dust, are associated with a large negative potential gradient. On one occasion a negative gradient of about 1650 volts/m. was measured. The author concludes that probably from 9 a.m. to 6 p.m. on the majority of days from March to June the potential gradient over a large portion of Northern India is negative and very large. This association of negative potential gradient with dust-storms is similar to that found by Rudge in South Africa [see Abstract No. 657 (1918)]. J. S. Di.

DISCHARGE AND OSCILLATIONS.

1026. Ionisation of Potassium Vapour by Ultra-violet Light. S. H. Anderson. (Phys. Rev. 1. Ser. 2. pp. 288-286, March, 1918.)—The general method of determining the ionisation of potassium vapour by ultra-violet light consists in measuring the current produced between two electrodes which are placed in a highly exhausted tube containing K-vapour, when a given p.d. is applied across the electrodes and a beam of ultra-violet light is passed through the vapour between the electrodes. The minimum current observed at a temperature of 55°C . is 1.5×10^{-10} amp., which is an order of magnitude quite different from the currents due to ionisation of any other vapour or gas by ultra-violet light. When the tube is maintained for some time at 55°C . an increase occurs in the conductivity which is not easy to explain, and it is further observed that a current of the same order can then be obtained at room temperature, although before heating no current at all could be detected. It is suggested that this increase in ionisation is due to the addition of traces of foreign gas.

A. E. G.

1027. Mobility of Ions in Dense Media. H. J. van der Bijl. (Deutsch. Phys. Gesell., Verh. 15. 6. pp. 210-218, March 80, 1918.)—A continuation of previous work [see Abstract No. 108 (1918)]. A new method was used to determine the distribution of the ions between two plates between which there was a strong field. The distribution curve was then used to determine the ionic mobilities. If t_0 is the point where the curve cuts the time axis, P the difference of potential between the plates and d the distance apart, then the mobility u is given by $u = d/t_0P$. This formula gives the mobility of the positive or negative ions according as the field is positive or negative. Experiments were carried out with hexane and carbon tetrachloride. For hexane the mobilities of the positive and negative ions were found to be 5.70×10^{-4} and 4.07×10^{-4} (cm./sec.)/(volt/cm.). The corresponding values obtained by Jaffé were 6.08×10^{-4} and 4.17×10^{-4} . For carbon tetrachloride the values were 2.44×10^{-4} and 2.42×10^{-4} , which are in fair agreement with the value 2.28×10^{-4} previously obtained by the author.

A. W.

1028. Ionisation produced by Heated Salts. C. Sheard. (Phil. Mag. 25. pp. 870-889, March, 1918.)—Experiments were made with CdI_2 heated to various temperatures up to the melting-point 402°C . The salt was heated in a tube A connected to a tube B, and it was shown that there could be a large ionisation in B even with a saturation potential in A. This suggests that the ionisation is partly due to the vapour. It was found that on heating the original salt there is a large negative emission and practically no positive. As the heating continues the positive ionisation increases to a maximum and then falls away; the negative continually diminishes. Further experiments showed that iodine alone gives large currents when heated, and a comparison with CdI_2 showed that some, at least, of the negative ionisation effects are probably due to the subsequent ionisation of the iodine vapour which is liberated by chemical dissociation in visible quantities.

E. M.

1029. Photoelectric Emission of Electrons from Calcium. R. Pohl and P. Pringsheim. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 111-122, March 15, 1918.)—The results obtained with Mg and Al have already been given [see Abstract No. 1412 (1912)]. Ca is now found to possess for the wave-length

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interval 280 to 700 μ a normal photoelectric electron emission, *i.e.* the number of electrons emitted per unit of absorbed light-energy is independent of the orientation of the electric light-vectors. The curve, which shows the number of electrons emitted per calorie of light energy as function of the wavelength, has a maximum between 800 and 400 μ . The maximum with equal light absorption occurs so much the sharper the smaller the angle of incidence of the light. The reason for this is, that in the ultra-violet where the light penetrates deeply into the feebly reflecting Ca, only a very small proportion of the liberated electrons are able to escape from the metal, while when the light is absorbed in a relatively thin layer the greater part of the electrons set free escape from the surface of the metal. It is shown that the maximum with Ca cannot be identified with the resonance maximum of selective photo-effects. [See also Abstract No. 1082 (1918).] A. E. G.

1030. *Photoelectric Properties of Thin Platinum Films.* J. Robinson. (Phil. Mag. 25. pp. 115-182, Jan., 1918.)—A further study of the effect described by Stuhlmann [see Abstracts Nos. 260 (1911) and 1408 (1912)], with especial regard to the critical thickness of the film for which the photoelectric current and the velocities of the electrons are the same on the incident and the emergent sides. It is found that this happens at the same value of the thickness in both cases. The dissymmetry for velocities is not so strongly marked as for currents. As the thickness of the film increases through the value 10^{-7} cm., the photo-current increases suddenly. The ratio of emergent to incident current is constant for films thinner than 10^{-7} cm., and begins to diminish after the sudden increase in current has set in. Radiations from the spark produce much quicker electrons than those from the arc. The dissymmetry is more strongly marked the quicker the electrons produced. It is shown that it is possible that photo-electrons possess sufficient energy to ionise molecules of platinum, and that it is this which leads to the best explanation of the sudden rise of the photo-current at 10^{-7} cm. The thickness of film which gives the sudden rise of current is the same for slow and quick-moving electrons. The orientation of the plane of polarisation of the light has no influence on the dissymmetry. E. E. F.

1031. *Formation of Nuclei in Gases by Ultra-violet Light.* F. Bortini. (N. Cimento, 5. Ser. 6. pp. 101-118, Feb., 1918.)—Repeating the experiments of C. T. R. Wilson and of Sachs [Abstract No. 918 (1911)], but filtering the gases through asbestos, and avoiding rubber connections, the author finds that, contrary to these investigators, even much beyond the ratio $v_2/v_1 = 1.88$ no formation of cloud occurs. Ammonia forms nuclei having a radius of 8.7×10^{-7} cm., and air containing CS_2 nuclei with a radius of 5.95×10^{-7} cm. No nuclei are produced with nitrogen in presence of water-vapour, and no hydrogen peroxide could be detected in this case, even after prolonged exposure to ultra-violet light. The results obtained support Lenard and Ramsauer's conclusions that the formation of cloud is due to the production of solid chemical compounds by the action of the light. W. H. St.

1032. *Selective Photo-effect in Relation to Absorbed Light-energy.* R. Pohl and P. Pringsheim. (Deutsch. Phys. Gesell., Verh. 15. 6. pp. 178-185, March 30, 1918.)—In the previous experiments carried out to investigate the selective photo-effect of the alkali metals the authors have considered the number of electrons generated per unit of incident light-energy as a function of the wave-length [see Abstract No. 1749 (1910)]. The object of the present

experiments is to determine the relation between the number of electrons liberated per unit of *absorbed* light-energy and the wave-length. It is found that the resonance maxima of the selective photo-effects for K and Na become much more pronounced, in comparison with the simultaneously present normal effect, so soon as the number of liberated electrons per unit *absorbed* light-energy is considered as a function of the wave-length. The resonance regions of the selective photo-effects coincides with the regions of higher optical reflection. The total charge carried by the electrons, emitted on account of the absorption of one calorie light-energy, amounts to in the middle of the resonance regions for K about 50×10^{-4} , and for Na about 120×10^{-4} coulomb. These values are considerably increased for the coloured colloidal modifications, so that for both K and Na the charge amounts to about 850×10^{-4} coulomb/cal., and gives resonance curves of a sharpness which have not previously been observed in unpolarised light. The influence of the colloidal state cannot in this case be ascribed to increased absorption of light, but the cause must be looked for in the extremely small diam. of the metal particles.

A. E. G.

1033. *Presence of Helium in the Gas from the Interior of an X-Ray Bulb.* W. Ramsay. (Chem. Soc., Journ. 108. pp. 264-266, Feb., 1918.)—In a previous note [Abstract No. 1788 (1912)] the author stated that the residual gas extractable by heating the glass of an X-ray bulb contained a measurable trace of He, in which the Ne spectrum could also be identified. In the present paper the experiment is described in more detail, and the result confirmed as follows: The exit tube of an old X-ray bulb was connected by means of thick-walled rubber tubing with a Töpler pump, the drawn-out end of the exit tube having previously been scratched with a glass knife so that it could be broken through the rubber by the help of pliers. Before this was done, all air was pumped out of the connecting tube. The X-ray bulb stood in an air-bath of asbestos card, and was heated to about 850° . After a c.cm. of pure oxygen had been admitted to "wash" out the X-ray bulb the gases were pumped off and placed in contact with charcoal cooled by liquid air in order to condense out all gases except H, He, and Ne. The residual gas then gave the spectrum of He, the two stronger red lines of Ne also being visible. This process was repeated with two more X-ray bulbs, and the volume of the combined residual gases was 0.89 mm.³. Test experiments were tried which showed that the effect was real, and that the gas was not derived from any air which might have leaked in.

E. M.

1034. *Experiments on the Electrical Discharge in Helium and Neon.* H. E. Watson. (Cambridge Phil. Soc., Proc. 17. No. 1. pp. 90-107, Feb. 14, 1918.)—This investigation, which is of a preliminary nature, had as its original object the determination of the cathode-fall and minimum potential necessary to produce a spark between two electrodes in all inactive gases. Measurements have been made of the spark potentials, at different pressures, between plane Al electrodes in very pure helium and neon, no external exciting agent being used. With electrodes 15 mm. apart the normal minimum spark potentials, excluding a lower value obtained on the first passage of the current, are found to be 184 and 200 volts for He and Ne respectively, the corresponding pressures being 2.4 and 2.8 mm. respectively. For a perfectly uniform field the p.d.'s might possibly be 2 or 8 volts less. At pressures higher than these the curve connecting spark potential and pressure does not assume a linear form until the pressure rises to about 10 mm. After this point the

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gradients are 80 volts per cm. pressure for He, and 22 volts per cm. for Ne. The kathode-fall with Al electrodes which have been well "run" is at most 164 volts for He and 170 volts for Ne. Consequently, it does not appear to be equal to the minimum spark potential. With a kathode of sodium-potassium alloy in Ne the minimum spark potential is near to and not greater than 145 volts, and the kathode-fall is 85 volts. The kathode-fall in Ne with kathodes of Cu, C, Mg, and Ca is approximately 221, 217, 150, and 150 volts respectively. Four abnormal and alternative forms of discharge are observed : (a) Corresponding to a state of very high resistance in the gas under examination ; (b) a variation of this corresponding to a transition stage between it and the normal discharge ; (c) an intermittent discharge, the frequency of which can be controlled ; and (d) corresponding to the discharge from a Wehnelt kathode. The fatigue of the electrodes is found to be considerable and of two kinds. Firstly a true fatigue, and secondly a reluctance to allow the current to start a second time when one discharge has already passed. Measurements made on the efficiency of the light from the negative glow show this to be less than was to be expected. Peculiar physiological effects corresponding to arc blindness are also observed. A. E. G.

1035. *Disruptive Discharge due to the Combined Action of Two Striated Positive Columns.* A. Wehnelt. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 140-142, March 15, 1918.)—The discharge tube used is Y-shaped, having two kathodes, one on each of the arms, the anode being placed at the end of the third branch. It is arranged that one kathode can be adjusted at will. When the movable kathode is placed so that the striations of both systems exactly coincide, a steady striated positive column is seen in the common portion of the tube, and the discharge is continuous, as is indicated by a telephone and rotating mirror. When the striations due to one arm fall exactly between those due to the other arm a disruptive discharge occurs in the common branch. The telephone in circuit gives a very high note, and the rotating mirror indicates that the striations follow each other exceedingly rapidly. On this account, to the naked eye, the positive column appears almost unstriated. These experiments succeed equally well for all pressures at which a clearly defined striated column is obtainable. A. E. G.

1036. *Presence of Neon in Hydrogen after Passage of Electric Discharge through the latter at Low Pressures.* J. N. Collie and H. S. Patterson. (Chem. Soc., Journ. 108. pp. 419-426, March, 1918.)—This communication is divided into two parts, as both authors independently approached the problem from different points of view. Some years ago Collie noticed that many minerals, notably sodalite and fluorspar, change colour when bombarded by kathode rays ; at the same time much gas is given off. He had also noticed that neon was present in the gas emitted from calcium fluoride under the action of the kathode rays [see Abstract No. 1788 (1912)]. It is found to be excessively difficult to get calcium fluoride in a condition so as to give no gas when bombarded by kathode rays. As this gas consists almost entirely of carbon monoxide, hydrogen, oxygen, and a trace of silicon fluoride, it had presumably been formed from the calcium fluoride, water, and carbonaceous matter in the tube. The above mixture of gases is sparked, then treated with liquid air and charcoal, and the residue, which contains neon, forced up into a capillary tube, where its spectrum can be obtained. In all, 85 experiments, some of which are described, have been carried out for the purpose of investigating this point, and neon was found every time. The investigation
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was undertaken by Patterson with the object of endeavouring to verify certain deductions from the formula for electronic mass, $m = 2e/8a$. Since the electric charge on the α -particle is twice that on the hydrogen ion, while their masses are in the ratio of 4 to 1, it follows that the radius of the seat of the major part of the mass of an atom may be the same in each case. If therefore, by means of the electric discharge, a second electric charge could be given to the seat of mass of the hydrogen ion, an α -particle might be produced, in which case it would be possible to convert a hydrogen atom into one of helium. One way of attempting to verify these deductions seemed to be to subject hydrogen at a low pressure to the electric discharge, and, after removing the excess of hydrogen, to examine the residue in a small spectrum tube. The facts obtained as the result of the combined experiments appear to be as follows:—Neon cannot be obtained from either the glass or the electrodes by heating alone. The neon found is not due to air leaking in during experiment. Glass, either when heated to near its softening point, or under the action of cathode rays, is not permeable to ordinary neon or helium. The hydrogen and the oxygen used did not contain neon.

The explanation of these facts remains an open question. A. E. G.

1037. *Dynamical Characteristics of the Wehnelt Valve Tube.* R. A. Porter. (Ann. d. Physik, 40. 8. pp. 561–601, March 20, 1918. Extract of Dissertation, Göttingen.)—It is found that the lighting tension, for a given pressure and frequency of alternating current, is apparently a constant for the tube, which shows that it is independent of the glow temperature of the cathode. It decreases with increasing pressure and is influenced by the nature of the gas contained in the tube, the lighting tension for air being the highest, then that for hydrogen and oxygen, and finally that for air containing mercury vapour. It increases with increasing frequency. The statical and dynamical characteristics of the tube have been measured. The alteration of the dynamical characteristic is investigated when tension, resistance, cathode temperature, pressure, frequency, and nature of the contained gas are separately varied. It is found that this characteristic shows marked hysteresis effects. An explanation of the phenomena based on the ionic theory is put forward.

A. E. G.

1038. *Electrical Vibrations associated with Thin Rods.* H. M. Macdonald. (Phil. Mag. 25. pp. 427–428, March, 1918.)—In reply to Rayleigh's treatment of this case [see Abstract No. 667 (1918)], the author puts forward the view that the disturbance in the immediate neighbourhood of the free end that gives rise to the radiation in question appears to be of the same kind as in the electrical discharge from a conductor with a sharp point on it.

E. H. B.

1039. *Propagation of Hertz Waves along Metal- and Liquid-surfaces.* F. Erb. (Jahrbuch d. drahtlosen Telegraphie, 6. pp. 521–541, March, 1918. Extract from Dissertation, Braunschweig.)—The author investigates the propagation of Hertz electric waves along the surface of metal and of salt solutions. The apparatus is carefully described. To determine the direction of the incident radiation a special receiver is used consisting of five simple receivers mounted parallel to each other on a glass plate with the thermocouples connected in series. The wave-length employed is 16.7 cm. The experiments show that the radiation is partly reflected at the edges of the metal path, and that in consequence the radiation follows along the surface of a metal path bent in its own plane. Around the surface of a metal

cylinder the radiation energy falls off in a manner which agrees tolerably with the Poincaré-March formula. Along the surface of salt solutions the radiation energy falls off much more quickly than theory requires. T. P. B.

1040. *Effect of Functions on the Propagation of Electric Waves along Conductors.* Rayleigh. (Roy. Soc., Proc. Ser. A. 88, pp. 108-110, Feb. 24, 1918.)—An experiment of Hertz suggests to the author some interesting problems in electric-wave propagation. In its original form waves of the simplest kind travel in the positive direction, outside an infinitely thin conducting cylindrical shell which comes to an end at a given plane. Coaxial with the cylinder a rod or wire extends to infinity in both directions. The conductors being supposed perfect, it is required to determine the waves propagated onwards beyond the cylinder on the positive side of the plane, as well as those reflected back outside the cylinder and in the annular space between the cylinder and the rod. To bring the problem within the scope of approximate methods an external coaxial conducting sheath is introduced extending to infinity in both directions, the diam. of the sheath being small in comparison with the wave-length of the vibrations. Equations are then derived, in the first place for waves in two dimensions, and some of these are found to be identical with those which apply in two dimensions to aerial vibrations executed in spaces bounded by fixed walls. The analogy throws light upon the question under what circumstances electric waves are guided by conductors. Some high authorities regard such guidance as ensuing in all cases as a consequence of the boundary condition fixing the direction of the electric force, but in acoustics, though a similar condition holds good, there is no guidance of aerial waves round convex surfaces, and it follows there is none in the two-dimensional electric vibrations under consideration. Near the concave surface of walls there is in both cases a whispering-gallery effect. The extreme case of Hertz's problem (as modified) is next considered, viz. when all the radii of the cylindrical surfaces concerned become infinite, followed by the other cases. The success of the method used in the problems depends upon the assumption of a great wave-length, which, while constituting a limitation, has the advantage of eliminating the irregular motion at the junctions. H. H. Ho.

1041. *Hertzian Oscillations from Kathode.* K. Birkeland. (Comptes Rendus, 156, pp. 879-881, March 17, 1918.)—Electrical oscillations are found to be produced by the intermittent discharge emanating from isolated spots on the kathode of a Crookes tube. E. H. B.

1042. *Emission of Particles by Heated Silver.* D. M. Shaw. (Nature, 90, p. 594, Jan. 30, 1918.)—Discusses the effects of heated silver in contact with surfaces of porcelain, plaster of Paris, etc. E. M.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1043. *Electric Conductivity of Glass and Rock Crystal.* R. Ambronn. (Phys. Zeitschr. 14, pp. 112-118, Feb. 1, 1918.)—It was found necessary to use polarisable electrodes of burnt-in platinum. On account of electrolysis the current was made alternating through the specimen, but was measured as direct current on account of the small e.m.f. necessary. It is shown that the law of constant equivalent conductivities of dilute solutions is applicable
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to the constituents of the glass. Constants are evaluated for Na_2O , CaO , and SiO_2 . The results obtained with rock crystal show that whatever electric conductivity there is is due to sodium ions, which are only capable of moving along the principal axis. Conduction is, therefore, only obtained if parts of the platinised surfaces serving as electrodes are joined by conducting filaments parallel to the principal axis. E. E. F.

1044. *The Effect of Magnetic Fields on Resistance.* C. W. Heaps. (Phil. Mag. 24. pp. 818-819, Dec., 1912.)—The author in a former paper described experiments on the resistance of iron, nickel, cadmium, and Heusler alloy in transverse and longitudinal fields. The present paper gives an account of experiments undertaken to find whether it is a general rule in all para- and dia-magnetic metals for a transverse field to produce a greater effect than a longitudinal, and natural crystals were specially investigated. The following are the results arrived at:—(1) For para- and dia-magnetic metals a transverse field produces a greater increase of resistance than a longitudinal field, and for small magnetising forces the increase is proportional to the square of the field strength. (2) Crystals of lead sulphide in a magnetic field behave like an isotropic para- or dia-magnetic metal. (3) The resistance of iron pyrites is unaltered by a magnetic field, and the change, if any, is less than 2×10^{-6} per ohm for a field of 10,000. (4) Whatever the direction of the magnetising force the resistance of molybdenite decreases. (5) The behaviour of magnetite in a magnetic field indicates that it has a very complex internal structure. For fields over 4000 or 5000 after saturation dR/R and H are always connected in a linear relation. This indeed appears to be a general rule in high fields. For a non-magnetic substance crystallising in regular form the internal structure may have no effect on the change of resistance in a magnetic field, but for ferro-magnetic metals the crystalline character may play an important part, since the orientation of the minute crystals may influence the general change of resistance caused by magnetisation. J. J. S.

1045. *Determination of High-frequency Resistance.* L. Högelsberger. (Deutsch. Phys. Gesell., Verh. 15. 5. pp. 167-170, March 15, 1918.)—The author determines the resistance of a secondary oscillation circuit coupled to a primary by inserting two inductionless resistances in the circuit and determining the resonance deflections of the galvanometer, first when there is no added resistance, and then in the two cases when the resistances are inserted in the circuit. T. P. B.

1046. *Resistivity of Metals.* E. F. Northrup and V. A. Suydam. (Frank. Inst., Journ. 175. pp. 153-161, Feb., 1918.)—Observations were made on the resistivity of Cd, Pb, Sn, Zn, Bi, and Sb, at various temperatures from about 20°C . to near the boiling-point of the substance. The results are given in curves and a series of tables, but a description of the method of investigation is deferred till a subsequent paper. J. J. S.

1047. *Influence of Temperature and Pressure on the Electrical Resistance of Metals.* E. Grüneisen. (Deutsch. Phys. Gesell., Verh. 15. 6. pp. 186-200, March 30, 1918.)—The more important points in this paper are as follows:—The electrical resistance of pure metals increases at very low temperatures proportionally to a universal function of $T/\beta V_m$, where V_m is determined by the atomic heat, and β is the known constant h/k of Planck's radiation theory.

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The reasons for the adoption of this function, in place of that calculated by Wien for resistance, are given. The assumption made by Wien, that the number of collisions between electrons and atoms, or the reciprocal free path, is proportional to the square of the atomic amplitude, receives support. The electrical resistance of pure metals in sign and order of magnitude under the influence of hydrostatic pressure is considered, as is also the pressure effect upon alloys.

A. E. G.

1048. Dielectric Constant of Air at High Pressures. A. Occhialini and E. Bodareu. (N. Cimento, 5. Ser. 6. pp. 15-40, Jan., 1918.)—The dielectric constant of air has been measured at pressures up to 175 atmos., the results obtained being—

Pressure (atmos.) ...	60	95	115	140	150	175
D.....	1.0857	1.0567	1.0684	1.0889	1.0908	1.1058

which agree well with those of Tangl [Abstract No. 1565 (1907)], and the values found for refractive indices by Magri [Abstract No. 1912 (1904)]. The ratio $(D - 1)/(D + 2) \cdot (1/d)10^6$ is almost constant, varying only between 194 and 196, but the expression $(D - 1)/d \cdot 10^6$ tends slightly to increase with the density.

W. H. S.

1049. Study of Resistance of Carbon Contacts. A. L. Clark. (Phys. Rev. 1. Ser. 2. pp. 50-55, Jan, 1918. Electrician, 71. pp. 262-268, May 28, 1918.)—During some experimental work with telephone transmitters, it was found that the resistance of carbon contacts varied not only with pressure and current, but also with time and in a very regular manner. This paper is an account of an investigation of the time relations of changes in resistance in carbon contacts such as are commonly used in telephone transmitters. Experiments were made on carbon in the form of grain, balls, and plates, always with the same results. Loose contacts were studied first. It was found that when a small current was sent through such contact there is a very regular decrease in resistance, which seems to be permanent if the contact is not disturbed. The slightest jar disturbs the contact in such a way that the phenomenon repeats itself. If a strong current is followed by a weak one, the weak one has no effect on the resistance. It is not certain that there is no recovery from this change of resistance, but there is no experimental evidence to show that such recovery occurs. The sensitiveness of a loose contact to change in pressure is remarkable. It was found that shifting the weight from one foot to the other distorted the floor and table sufficiently to change the pressure and show a decided effect in the milliammeter. The table below shows the results of several successive runs beginning with a low e.m.f. and increasing to a value below the critical point. After the first run, the resistance changes very little.

Volts.	Resistance.			
0.4	445	808	296	296
0.6	888	289	287	277
0.8	254	222	286	286

When the e.m.f. passes a certain critical value the phenomenon changes. The resistance increases regularly with time. The critical value depends

somewhat on the contact pressure as previously noted by Bidwell. It also depends upon contact area, so that the critical value probably depends upon current density rather than applied e.m.f. The higher the current density, the more rapid is the rise in resistance. The resistance rises rapidly at first and then more slowly. If the current be interrupted at any time and the circuit be left open for an hour or two and then closed, the resistance begins with the same value as when the current is interrupted and the curve is continuous unless the contact has been jarred. With large e.m.f.'s but still so small that no arc forms, the resistance rises rapidly to infinity. The phenomena are totally different when the pressure becomes great enough to break down the non-conducting layer.

From the table given below, it is doubtful whether in the case of tight contact, there is a change in resistance with time.

Time. Minutes.	Volts.								
	0.06	0.21	0.4	0.56	0.72	0.88	1.09	1.60	1.9
0	4	8	2.9	8.4	8.2	2.82	2.66	1.54	1.29
$\frac{1}{2}$	4.8	8	2.9	8.88	8.18	2.77	2.68	1.55	1.28
1	4.4	8	8.2	8.8	8.25	2.99	2.6	1.54	1.28
$1\frac{1}{2}$	4.2	8	8.8	8.28	8.25	2.88	2.6	1.50	1.25
2	4.4	8	8.28	8.88	8.22	8.08	2.55	—	—
$2\frac{1}{2}$	—	—	8.27	8.84	8.22	2.92	—	—	—
3	—	—	8.26	8.84	—	—	—	—	—

In some cases of tight contact it has been found that the resistance decreases with time, but if the current be interrupted for a few minutes the resistance has a much smaller value than when the current was interrupted. The paper is accompanied by four curves. H. H. H.

1050. *Rectification by Photoelectric Cell.* S. H. Anderson. (Phys. Rev. 1. Ser. 2. pp. 222-282, March, 1918.)—An experimental research yielding the following results:—(1) The rectifying power of a photoelectric cell, using potassium for the active electrode, was found to be of the ratio 2000 to 1. (2) The general form of the rectified cycle is the same for the different pressures, electrode distances and potentials used. (3) The amount of the current for a given potential depends on the pressure of the gas, the electrode distance, and the intensity of light falling on the cell, but does not increase continuously with increasing intensity. (4) Nitrogen at a pressure of about 5 mm. combines with potassium or is absorbed by it when a glow discharge passes. (5) The high power of rectification and the high resistance of the photoelectric cell indicate that it may be very efficient as a detector of electric waves. [See Abstract No. 482 (1918).] E. H. B.

1051. *The Thomson-effect.* H. R. Nettleton. (Phys. Soc., Proc. 25. pp. 44-64; Discussion, pp. 64-65, Dec., 1912.)—When a current of electricity passes down a conductor in which a temperature gradient is maintained, the stationary value of the temperature at any place is dependent to a small extent on the direction of the current, for heat is evolved or absorbed in accordance with the Thomson-effect. The relation between the heat evolved or absorbed, the temperature gradient and the current was expressed by
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Kelvin in the form $dQ = C\sigma \cdot d\theta$, where dQ = heat evolved or absorbed per sec. by a current C in passing between two sections differing in temperature by $d\theta$, σ being the specific heat of electricity. An investigation was made by the author of the distribution of temperature down a conductor conveying an electric current and at the same time moving uniformly through two fixed temperature sources. The effect of the Thomson heat on the distribution is exactly similar to the effect of a small impressed velocity. Thus in the case of mercury the Thomson-effect is measured by comparing the alteration of temperature $\Delta\theta_1$, at a point near the middle of the gradient caused by reversing a current of C amps. with the alteration of temperature $\Delta\theta_2$, at the same point due to a flow of mercury of m gm. per sec. It is shown that without any approximation as to emissivity loss or magnitude of Joulian heat, $2C\sigma ms = \Delta\theta_1/\Delta\theta_2$, where s is the specific heat of mercury and σ the specific heat of electricity. With currents of from 4 to 9 amps. and with various flows (not exceeding 1 cm. per hour) consistent values of σ were obtained, the value at 61°C. being -1.52×10^{-6} cal. per 1 deg. C. per coulomb. The thermo-junctions—iron and constantan—were fused through the glass tubes with inappreciable distortion. J. J. S.

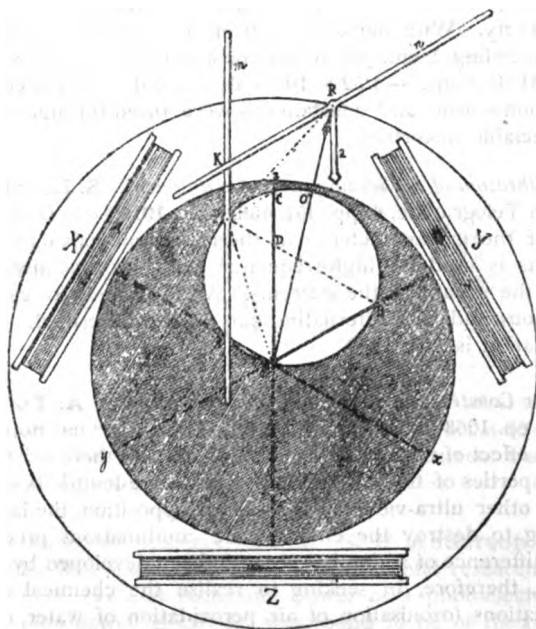
1052. *Calibration of a Thermo-couple Arrangement.* S. Loewe. (Jahrbuch d. Drahtlosen Telegraphie, 6. pp. 451–458, Feb., 1918.)—It is shown that the deflections of the galvanometer in a thermo-couple-galvanometer arrangement, such as is used for high-frequency work, are not always truly proportional to the square of the currents. Arrangements for calibration both with continuous and with alternating current are described. The accuracy of the calibration is 1 in 1000. T. P. B.

1053. *New Construction for Quartz Mercury Lamps.* A. Tian. (Comptes Rendus, 156. pp. 1063–1064, April 7, 1918.)—The author has noted, in connection with the effect of ultra-violet light on water, that there exists between the chemical properties of the rays of very short wave-length ($\lambda < 1900 \text{ \AA.}$) and those of the other ultra-violet radiations an opposition, the latter radiations often tending to destroy the endothermic combinations produced by the first. This difference of action has recently been developed by Berthelot. It is necessary, therefore, in seeking to realise the chemical effects of the extreme radiations (ozonisation of air, peroxidation of water, decomposition of HCl, etc.), to make use of a source of these rays giving a proportion as feeble as possible of those possessing the opposite properties. Quartz mercury lamps are, on account of their convenience, always employed; for the present purpose they must be operated at low voltage, since the total emission of ultra-violet rays from this source increases enormously with the applied p.d. [Abstract No. 1716 (1911)], while the energy of the most refrangible rays ($\lambda < 1900$) varies relatively much less [Abstract No. 1857 (1912)]. The complex form of ordinary quartz lamps renders it somewhat awkward to immerse them in a liquid, especially when the source of light is required to be as close as possible to the object dealt with. The author has constructed several lamps more suitable for this purpose. The part of the lamp made of transparent quartz has the form of a test-tube. A little mercury at the bottom serves as cathode, and connection is made to this by an iron wire protected by a small tube of opaque quartz passing down the centre of the tube. The anode is a small cylinder of iron. A copper support at the top aids the cooling by conduction. The arc can be used either with direct or alternating current; in the latter case it is necessary to use two VOL. XVI.—A.—1918.

anodes consisting of small iron plates separated by a sheet of mica, and to provide a third electrode at the glass stopper. The lamp will work in all positions, ranging from the vertical to a small inclination to the horizontal.

A. W.

1054. *Kinematic Model for representing the Current and E.M.F. in a Three-phase System.* S. Marcucci. (N. Cimento, 5. Ser. 6. pp. 141-144, Feb., 1918.)—The arrangement proposed is shown in the Fig., where X, Y, Z are three arrows laid on a drawing table, along the sides of an equilateral triangle, Xx, Yy, and Zz being drawn perpendicular to them, and intersecting in O. Rotating on an axis at O is a glass disc on which is gummed paper, cut in



such a way that a margin is left uncovered all round, and also a circular window, whose edge passes through O. In the margin X, Y, and Z are always visible, and in the window the three segments OA, OB, and OC, these latter constituting a three-phase system, and representing not only the generating magnetic field, but also the currents themselves, and the e.m.f. The resultant magnetic field is represented by OR, obtained by producing the diameter OO' until $OR = (8/2)OO'$.

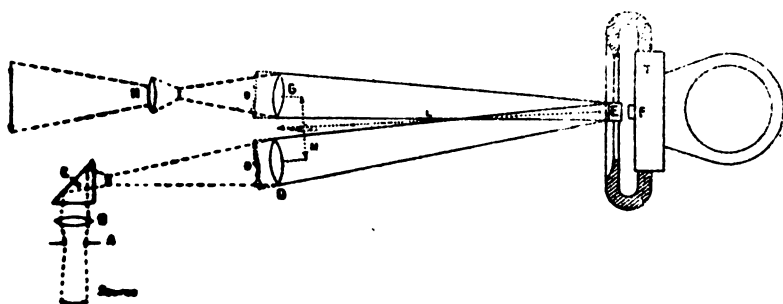
W. H. St.

1055. *Sensitive Moving-coil Galvanometer.* H. Rohmann. (Phys. Zeitschr. 14. pp. 208-209, March 1, 1918.)—The sensitiveness of a moving-coil galvanometer, which depends upon the size of the coil, the restoring couple, and the strength of the magnetic field, is still capable of considerable increase. An increase in the field strength leads to an increased damping, which varies as the square of the sensitiveness, and eventually leads to creeping. The author uses strong electromagnetic fields, and gives two methods of increasing the sensitiveness. In the first method, the field is

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initially given such a value that the moving coil is just aperiodic. A constant current then gives a deflection corresponding to the sensitiveness. This deflection is increased by raising the magnetic field to a higher value and then allowing it to return to the former strength. During this change of field induced currents are generated in the moving coil, which is short-circuited, and these currents are strong in comparison with the original current. They first draw the pointer towards the zero and then away from it, the last deflection being the larger. The magnification of the original deflection is about half the ratio of the two fields. In the second method a ballistic throw is increased in the same ratio by starting it in a strong field, which is then suddenly reduced. The ratio of magnification obtained is 8 or 9. E. E. F.

1056. *An Interference Oscillograph*. A. Guyau. (Comptes Rendus, 156, pp. 777-779, March 10, 1918.)—The measurement of the movements of a telephone diaphragm led the author to construct an oscillograph of the interference type by which it is possible to record photographically vibrations of small amplitude of the order of a few hundredths of a micron. Referring to the Fig., the interference figures are formed in a thin layer of air between a movable silvered mirror F glued to the surface whose vibrations are to be investigated, and a fixed reference mirror E. The mirrors are intensely illuminated by the image of a mercury quartz lamp by means of the optical



system BCD. The image of the fringes is projected with magnification by means of the system GH, on a horizontal slit behind which is placed a recording cylinder driven by a helicoidal gear. The exact image of the fringes is thus transmitted to a sensitised surface, and forms the curve of the displacement v of the fringes as a function of the time, and the distance v of two consecutive fringes fixes the scale by which the curve represents the displacement of the moving surface. This oscillograph has been applied to study the motion of a telephone diaphragm, and enables fragments of a conversation to be recorded. The natural frequency of the telephone has also been measured with the oscillograph and found to be $800 \sim$, and its damping (logarithmic coefficient) 400 approximately. The displacements being proportional to the intensity, the instrument can be used as an oscillograph-galvanometer. The paper gives the mathematical theory of the instrument. H. H. H.

1057. *Idiostatic Electrometer*. V. Crémieu. (Comptes Rendus, 156, pp. 460-468, Feb. 10, 1918.)—The author has devised a torsion electroscope to serve as a measurer of the conductivity of the air in experiments with radium. It is meant to supersede the rather unsatisfactory method of

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observation depending on the rate of collapse of the leaves of a gold-leaf electroscope. A piece of Al-wire (B) is curved at one end into a circle, and at its other end dips vertically downwards; between the two extremities 4 wires of silver of $\frac{1}{16}$ mm. are stretched, whose friction against the air serves to damp the movements of the arrangement. The support consists of a metallic ribbon 25 cm. long, 0.001 cm. thick, and 0.01 cm. wide, whose upper end is fixed in a small goniometer. The ribbon is surrounded by a metal tube which carries at the same level as the movable aluminium and silver piece two pallets. The whole is insulated by a piece of amber. When charged the pallets repel the movable Al piece B, and the current is measured by observing the rate of turning of B as compared with that produced by a known current. The instrument possesses solidity and sensitiveness. In a normal atmosphere the rate of fall is about 80° per hour, and a current causing a turning of 5° per hour can similarly be measured, and the limiting sensibility may be 10^{-13} amp. J. J. S.

1058. *New Type of Electrometer*. B. Szilard. (Comptes Rendus, 156. pp. 779-782, March 10, 1918.)—The author has developed a sensitive electrometer [see Abstract No. 147 (1910)] which is convenient to read, and is robust, while having dimensions comparable to voltmeters of ordinary type. The indicating needle and moving sector are in one piece, the controlling couple being furnished by a helical spring: as the moving member is not charged, it can be handled without putting the apparatus out of order or causing discharge. As a consequence, it is possible to employ a fixed scale empirically calibrated once and for all. A micrometer microscope is fixed near the scale, and this is rendered possible by the fact that the moving quadrant and index are at the same potential as the frame of the instrument. The capacity of the instrument is practically independent of the deflection, and the voltage is proportional to the charge. The sensibility of the instrument can be varied by adjustment of the helical spring. The average capacity of the instrument is about 2 cm. A current of the order of 10^{-11} amp. gives a deflection of 1 degree which is equivalent to a movement of the needle of about 0.7 mm. The paper includes a specification of the construction of the apparatus, and a number of measurements are described for which the apparatus is stated to be peculiarly applicable. H. H. H.

1059. *Torsion Electroscope in Radio-activity Measurements*. M. La Rosa. (Giornale di Scienze naturali ed economiche, vol. 29. Palermo, 1912. N. Cimento, 5. Ser. 6. pp. 50-60, Jan., 1918.)—Describes a new pattern of torsion electroscope of the quasi-unstable type (C. T. R. Wilson), capable of being adjusted so as to cover a wide range of potentials, and so as to present a large range of sensitiveness and be simple in use. A. D.

1060. *Conductivity of Solids*. E. Weintraub. (Amer. Electrochem. Soc., Trans. 21. pp. 49-67, 1912.)—Gives many useful tables compiled from data collected from various published researches. L. H. W.

1061. *Electron Theory of Metallic Conduction*. O. W. Richardson. (Amer. Electrochem. Soc., Trans. 21. pp. 69-92, 1912.)

1062. *The Oil-drop Method of Studying Electrical Phenomena in Gases*. R. A. Millikan. (Amer. Electrochem. Soc., Trans. 21. pp. 185-200, 1912.) [See Abstract No. 1745 (1910).]

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ALTERNATING CURRENTS AND MAGNETISM.

1063. Mean Magnetic Moment of a Vibrating Magnet. J. R. Ashworth. (Manchester Lit. and Phil. Soc., Mem. 57. 4. pp. 1-7, March, 1918.)—A magnet is supposed to vibrate in a given plane in a constant field without friction, and an expression is calculated for its mean magnetic moment in the direction of the controlling field. Giving different values to the extreme deflection, α , of the magnet, it appears that for a value of α little more than 180° on either side, the mean moment would vanish. As the oscillations increase beyond 180° the magnet would exhibit a mean moment in the contrary sense, and would apparently behave like a diamagnetic substance. The mean kinetic energy of the vibrating magnet is calculated by a similar method, and comparison shows that the mean moment vanishes a little before the energy of vibration has reached its maximum. When the vibrations pass into rotations, the diamagnetic character will still be in evidence. When the controlling field is set up by a similar neighbouring vibrating magnet which has the same period, the diamagnetic property disappears, and the energy reaches a maximum for an angle α of about 70° . If such a pair of magnets is in rotation, the magnetic moment vanishes. The behaviour mentioned presents features which are found when the residual magnetism of a ferromagnetic substance is raised in temperature, *i.e.* there is a decline of magnetic moment with rise of temperature, and, at or near the critical temperature, the phenomenon of recalescence is found, which shows that the rate of absorption of energy on heating, or of emission of energy on cooling, is extremely large. G. E. A.

1064. Measurement of the Work absorbed by Magnetic Hysteresis. G. Lignana. (Accad. Sci. Torino, Atti, 48. No. 8. pp. 181-195, 1912-1918.)—A rapid method is described for the measurement of work used up by magnetic hysteresis, making use of a ballistic electro-dynamometer. A special electro-dynamometer has been devised for the purpose, the movable spiral of which is circular, 49 mm. in diam., and wound on celluloid, the suspension being unifilar. The fixed spiral is of wire, 0.7 mm. in diam., wound on two bobbins of hard, seasoned wood, 23 cm. in external diam., and the two bobbins have a resistance of about 60 ohms. W. H. St.

1065. Hall-effect at Low Temperatures. H. Alterthum. (Ann. d. Physik, 40. 2. pp. 891-892, Feb. 4, 1918.)—The author refers to the work of Kamerlingh Onnes and Beckmann [Abstracts Nos. 698, 694, 695 (1918)], and gives the following table showing the values obtained by himself and by these observers :—

T	Au		Cu	
	K.O. & B.	A.	K.O. & B.	A.
290° abs.	7.27	7.04	4.95	5.28
20° „	9.79	8.57	6.60	6.05

Alterthum calculated the Hall coefficient of silver, according to his theory, from the diamagnetic susceptibility to be $R_0 = 1.10$, and in good agreement with this Onnes and Beckmann have found 1.018. J. J. S.

1066. *Distribution of Magnetic Field between the Poles of an Electromagnet.* **A. Marchetti.** (N. Cimento, 5, Ser 6, pp. 119-140, Feb., 1918.)—The author has measured the distribution of magnetic field between the poles of an electromagnet of the type used in magneto-optics, employing Corbino's method [Abstract No. 1148 (1910)] for the measurement of fields of 5000 to 16,000 units, and a slight modification of this method for feeblar fields. It is found that for a given intensity of magnetisation the field on the axis of the pole space becomes greater with increase of distance between the poles, tending to equal that in the corona; and for a given distance between the poles increase in the magnetising current produces a rise in the field in the pole space, until the ratio of the latter to the field in the corona reaches a constant value (which is always less than unity). W. H. S.

1067. *Hall-effect in Antimony.* **J. Becquerel, L. Matout, and [Miss] W. Wright.** (Comptes Rendus, 156, pp. 468-466, Feb. 10, 1918.)—Becquerel found [see Abstract No. 1448 (1912)] that the Hall e.m.f. in Bi is much greater at the temperature of liquid air than at ordinary temperature, and is the resultant of two effects which follow different laws: one, positive in sense, proportional to the intensity of the magnetic field; the other, negative in sense, attaining to saturation. With antimony the results are as singular, but differ from those observed in the case of Bi, and are still more unexplained. The method used was that of Hall: a current was sent through a sheet 1 mm. thick and the p.d.'s at two transversal points are given for laminæ of 1 mm. traversed by 1 amp., first in a bath of oil at laboratory temperature, then in liquid air. Three sheets were examined, one cut parallel to the principal cleavage plane, *i.e.* normal to the principal crystallographic axis, and thus with the magnetic field parallel to that axis. A second sheet was taken parallel to the crystallographic axis; and a third was cut at random from a mass of antimony and is referred to as the medium sheet. It was found that: (1) the Hall-effect (positive sense) is greater at low temperatures; (2) the phenomenon depends on the orientation of the crystals in the magnetic field: the medium layer gave a notably more intense effect than either of the two others; (3) the curves giving the p.d. as a function of the magnetic field are composed of two straight lines connected by a curved portion concave to the axis of field strength. A simple decomposition into two or more effects, as in the case of Bi, is not possible in this case. The question (as also in the case of Bi) whether impurities do not produce considerable modifications is important, and further experiments are to be made with regard to this. The law of variation of the effect with the intensity of the field has not yet been sufficiently determined, and the study of a substance like Sb, in which the Hall-effect departs from proportionality to the field, is important. J. J. S.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1068. *The Apophorometer*. J. Joly. (Phil. Mag. 25, pp. 801-811, Feb., 1918).—The name apophorometer signifies a measurer of sublimates. The instrument consists of a ribbon of thin Pt, about 6 cm. in length and 4-5 mm. in width, stretched between two forceps which are provided with binding screws so that a current can be sent through the ribbon, raising its temperature to any desired degree up to the melting-point of Pt. One of the forceps is movable parallel to itself, and is so acted on by a light spring that the ribbon is kept stretched. The substance to be volatilised is placed in the form of powder upon the ribbon. Beneath the ribbon a watch-glass is held in position by a movable support. When this watch-glass is in contact with the ribbon a second glass is placed on it, so that the ribbon is enclosed between the glasses for nearly its entire length. Over all a receiver fits, enabling an indifferent gas to be introduced around the heated substance, or a vacuum to be established. By raising the Pt strip to different temperatures the sublimates formed from different substances can be collected, weighed, and investigated, and in many cases a chemical analysis thus be carried out in a short time with very little material. The temperature is measured by observing the current used, the ribbon having previously been calibrated by observation of the melting of a few substances of known melting-point and observing the current necessary to obtain this temperature. Numerous examples are given of the use of this instrument in the investigation of minerals, chiefly sulphides, selenides, and tellurides. T. S. P.

1069. *Method of determining Vapour Densities at High Temperatures, and on a New Form of Quartz Manometer*. G. E. Gibson. (Roy. Soc., Edinburgh, Proc. 88, pp. 1-8, 1912-1918).—The manometer described is an improved form of the membrane manometer [compare Jackson, Chem. Soc., Journ. 99, p. 1066, 1911]. The apparatus is of quartz, and is so arranged that when the pressures on both sides of the membrane are the same a quartz mirror attached to the membrane is parallel to a second, fixed quartz mirror. The position of equilibrium is determined by a lamp and scale arrangement, the manometer always being used as a zero instrument, equilibrium being attained by adjusting the external (and measured) pressure. The vapour densities of mercury vapour were determined between 487 and 912° C., the average value being 100.2, which is 1 per cent. higher than the theoretical value, 99.21, calculated on the assumption that mercury vapour is monatomic. There is, however, a slight tendency towards a decrease at the higher temperatures, so that the discrepancy may be due to slight association. [See Abstract No. 428 (1911).] T. S. P.

1070. *Improved Apparatus for measuring the Conductivity of Electrolytes*. E. W. Washburn and J. E. Bell. (Amer. Chem. Soc., Journ. 85, pp. 177-184, Feb., 1918).—The following instructions were followed in building up a conductivity apparatus :—(1) Abandon the induction coil as a source of current and replace it by a high-frequency generator giving a pure current of a single frequency, free from the overtones present in the complex wave-system of the coil. (2) In measuring very high resistances (20,000 ohms or more)

replace the ordinary resistance box by one in which the units are free from both inductance and capacity, *e.g.* by thin films of metal. (8) Use a tuned telephone and an extended bridge wire, and make all measurements at the middle of the bridge; take as much pains in balancing the capacities in the bridge-arms as in balancing the resistances. Test measurements indicated that with the improved apparatus the conductivity of any solution of an electrolyte from conductivity water to a several-times normal solution could be determined with a precision of 0.01 per cent. with the greatest of ease, and that by careful work this degree of precision can be raised to 0.001 per cent. in most cases. The absolute values would be of a lower order of accuracy unless constant errors of 0.001 per cent. or more were all eliminated. T. M. L.

1071. *Optical Investigation of Solidified Gases. II. Crystallographic Properties of Hydrogen and Oxygen.* W. Wühl. (Roy. Soc., Proc. Ser. A. 88. pp. 61-69, Jan. 29, 1918.)—Liquid hydrogen when further cooled crystallises with great velocity in spite of the fact that the temperature is only 20° above the absolute zero. Radiating groups of needles are formed, but these are absolutely isotropic and are probably derived from forms of the cubic system. Liquid oxygen, on the other hand, becomes viscous before crystallisation sets in. The crystals formed in the viscous mass are not well developed: they grow only slowly, and altogether cease to grow if cooled too rapidly. These crystals, like the glassy material from which they separate, appeared to be isotropic, but were proved to be hexagonal with small double refraction like quartz. Cooling with liquid hydrogen causes the whole to change into a fine-grained mass of crystals, which are strongly doubly-refracting; the oxygen is therefore polymorphous. This is important, as most of the physical properties of solid oxygen have been measured at the temperature of liquid hydrogen, and are therefore those of the lower-temperature form. The vapour pressure of oxygen when the charcoal vacuum is turned off is 0.45 mm., rising rapidly to 1.11 mm. and then remaining constant for some time; the former value is probably the vapour pressure at the triple-point where two solid forms are in equilibrium with vapour: the latter is probably the value for a second triple-point, where crystals, liquid, and vapour are in equilibrium. Interest attaches to the analogy between oxygen and sulphur as polymorphous elements. T. M. L.

1072. *Chemically Active Nitrogen.* A. Koenig and E. Elöd. (Phys. Zeitschr. 14. pp. 165-167, Feb. 15, 1918.)—The authors describe experiments corroborating the views of Strutt [Abstract No. 1897 (1912)] and meeting the objections of Comte [Abstract No. 707 (1918)] concerning the existence of an active form of nitrogen. They absorbed the oxygen by means of hot copper, as proposed by Comte. It was found consistently that a progressive purification of the nitrogen, especially by removal of the oxygen, leads to a stronger and more persistent afterglow. The active modification of nitrogen probably consists of single N-atoms, whose recombination to inactive N₂ molecules is accompanied by the characteristic glow. E. E. F.

1073. *Chemically Active Nitrogen.* R. J. Strutt. (Phys. Zeitschr. 14. p. 215, March 1, 1918. From the English.)—In reply to Comte [Abstract No. 707 (1918)] the author describes experiments with nitrogen which forms no fog with phosphorus, but can be made to do so by adding 0.001 per cent. oxygen. With this nitrogen free from oxygen a beautiful glow was obtained. A further long passage over red-hot copper produced no difference in the
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glow, but passage through a tube cooled by liquid air increased it. The author suggests that this increase is due to the condensation of impurities capable of stopping the glow, and that the presence of such impurities may account for Comte's negative results.

E. E. F

1074. Periodic System and the Radio-elements. A. S. Russell. (Chem. News, 107. pp. 49-52, Jan. 31, 1918.)—It has been recognised that some of the longer-lived radio-elements, such as Ra, RaF, and RaEm, have definite places in the periodic system of the chemical elements. In the present paper the whole of the radio-elements are dealt with. The following rules are given : (1) Whenever an α -particle is expelled by a radio-element the group in the periodic system, to which the resultant product belongs is either two units greater or two units less, than that to which the parent body belongs. (2) Whenever a β -particle or no particle is expelled, with or without the accompaniment of a γ -ray, the group in the periodic system to which the resultant product belongs is one unit greater, or one unit less, than that to which the parent product belongs.

E. M.

1075. Radio-elements and the Periodic Law. F. Soddy. (Chem. News, 107. pp. 97-99, Feb. 28, 1918. Nature, 91. pp. 57-58, March 20, 1918.)—The paper is an extension of the discussion given by Russell [see preceding Abstract] and deals mainly with those radio-active products which appear to be chemically non-separable. Thus the products radio-thorium, UrX, ionium, and radio-actinium in the fourth group of the Periodic Table appear to occupy a place already occupied by the element thorium, and hence are non-separable from each other and from Th. The consideration indicates that almost every vacant place in the Periodic Table between Tl and Ur is crowded with non-separable elements of atomic weight varying over several units, and leads to the presumption that the same may be true in other parts of the table. Nothing further is necessary to explain the failure of all attempts to obtain numerical relations between the atomic weights. It may thus be predicted that all the end products, probably six in number, of the three radio-active series, with calculated atomic weights between 206 and 210, should be non-separable from "lead," the element which appears to have an atomic weight 207.1

Experimental results are given which indicate that Ac is produced from UrX through an intermediate substance. **N. R. Campbell.** (Ibid. p. 85, March 27, 1918.)

E. M.

1076. Application of the Principle of Relativity to Radio-chemistry. R. Swinne. (Phys. Zeitschr. 14. pp. 145-147, Feb. 15, 1918.)—Putting, with Einstein [Abstract No. 188 (1906)], the energy equivalent of 1 gm. = 9×10^{10} ergs, the author calculates the loss of atomic weight attributable to the energy of the expelled particles, apart from their weight. He finds that in the uranium series the energy expended in the various steps down to RaF involve a total loss amounting to 0.028 per cent. of the atomic weight. If such losses are taken into account, they may go some way towards explaining the deviations from the atomic weights required by Prout's hypothesis. In any case, they tend to compensate the amount by which the weight of the helium atom falls short of 4.

E. E. F.

1077. Decomposition of Water by α -Rays. W. Duane and O. Scheuer. (Comptes Rendus, 156. pp. 466-467, Feb. 10, 1918. Le Radium, 10. pp. 88-46, VOL. XVI.—A.—1918.

Feb., 1918.)—The decomposition of water in the solid, liquid, and gaseous state by the α -rays was studied. Whatever its state water is thus decomposed into O and H. In the gaseous state, as in the liquid, there was formation of H in excess, and this hydrogen in the former case attained 50 per cent. of the total volume of gas. The quantity of liquid water decomposed is proportional to the intensity of the radiation. The number of molecules of gas formed is 6 per cent. greater than the number of ions that the same α -rays would produce in air. The ratio of the number of molecules of gas formed to the number of ions produced is 1/20 for ice, and for the vapour 1/50 to 1/150 of that obtained for liquid water. J. J. S.

1078. *Electrochemical Properties of Radio-active Elements*. K. Fajans. (Phys. Zeitschr. 14. pp. 181–186, Feb. 15, 1918.)—From such facts as are available concerning the electrochemical behaviour of radio-active substances it is concluded that any radio-active transformation involving the expulsion of an α -particle generates an element more electro-positive than the parent element. Transformations produced by the expulsion of a β -particle, on the other hand, generate "nobler" elements. [Errata, Ibid. p. 257, March 15, 1918.] E. E. F.

1079. *Radio-active Elements and the Periodic System*. K. Fajans. (Phys. Zeitschr. 14. pp. 136–142, Feb. 15, 1918.)—The electro-chemical behaviour of the radio-active elements [see preceding Abstract] may be most simply summarised by saying that the expulsion of an α -particle moves the element two places to the left in the periodic system, while the expulsion of a β -particle, while leaving the atomic weight unchanged, moves the element one place to the right. All the known radio-active elements may then be grouped in the periodic system. The emanations are placed in Group 0. Group 2 contains AcX, ThX, Ra, and Meso-Th. Group 3 contains Ac and Meso-Th, together with a group of lower atomic weight comprising Tl, AcD, ThD, and RaC. Group 4 contains Radio-Ac, Radio-Th, Io, Th, and UrX, together with Pb, RaD, AcB, ThB, and RaB, each of which is two units higher than the last. Group 5 contains Bi, RaE, AcC, ThC₁, and RaC₁. Finally, Group 6 contains Ur, and Ur₁, with the secondary group RaF, ThC₂, RaC, AcA, ThA, and RaA. The author believes that this successful grouping of the radio-active elements confirms the supposition that the periodic system owes its origin to radio-active evolution. E. E. F.

1080. *Chemical Nature of some Radio-active Disintegration Products*. A. Fleck. (Chem. Soc., Journ. 103. pp. 881–899, March, 1918.)—The paper contains details of numerous experiments on the separation of mixtures of various radio-elements and other substances. It is shown [see also Abstract No. 1768 (1912)] that UrX and radio-actinium are chemically similar to and non-separable from thorium; mesothorium 2 is non-separable from actinium; ThB is non-separable from Pb; RaB and AcB are extremely similar to Pb and probably non-separable from it; ThC₁, RaC, and AcC are very closely allied to Bi and probably chemically similar to it. For the details of the methods tried the original paper must be consulted. By measurements of the direct growth of RaF from RaE the author concludes that the latter consists of one product only. RaE is shown to possess chemical properties identical in all respects with those of Bi. E. M.

1081. *Alloys of Aluminium with Vanadium*. N. Czako. (Comptes Rendus, 156. pp. 140–142, Jan. 18, 1918.)—A series of these alloys containing VOL. XVI.—A.—1918.

up to 80 per cent. V have been prepared by the aluminothermic method. Microscopic analysis and the examination of residues yield definite evidence for the existence of the compounds Al_3V and AlV , while the existence of the compound AlV , seems probable. Up to about 10 per cent. V the alloys are malleable; above this they become more and more hard and brittle, the maximum hardness being attained at about 58 per cent. V (Al_3V).

F. C. A. H. L.

1082. *Effect of High Carbon on Charcoal Iron.* J. E. Johnson, Jr. (Amer. Inst. Mining Engin., Bull. No. 74. pp. 178-214, Feb., 1918. Metallurgical and Chem. Eng. 10. pp. 777-788, Dec., 1912.)—Contains an account of investigations on the properties of charcoal iron from which it is concluded that spotted irons, containing a white chilled spot in the centre of the pig are products of carbon segregation, and that this segregation may take place in irons containing either more or less carbon than the eutectic ratio; further, that the segregation is less marked and less likely to have ill-effects the further the carbon is below the eutectic ratio. It is also shown that when the fracture of an iron shows high cleavage at the edge, it is generally up to or above the eutectic ratio and is a weak iron. Close spots, not associated with cleavage, may occur in irons of good quality, especially where the silicon is comparatively high.

C. O. B.

1083. *Notes on Cast-iron.* A. Sauveur. (Amer. Inst. Mining Engin., Bull. 75. pp. 508-524, March, 1912.)—Consists of general notes on the physical properties of cast-iron, the ultimate and structural composition, etc. Shows that a knowledge of the ultimate composition is not sufficient, and that a knowledge of the size, form, and mode of distribution of the graphite is important in relating the properties and composition. Cast-iron of maximum strength should have a eutectoid or slightly hyper-eutectoid matrix, that is, it should contain about 0.8 % combined carbon, and the graphite particles should be few in number, i.e. the total carbon should be low. These graphite particles should not be present as sharp long plates, but as rounded star-like particles. The formation of this form of carbon may be assisted by relatively quick cooling during and below solidification. Another important factor is Si-content, and for small castings higher Si is necessary than for large castings. It is pointed out that a knowledge of the proximate composition of cast-iron should be of greater value than a knowledge of its ultimate composition, the important proximate constituents of commercial cast-iron being: (1) elemental carbon or graphite; (2) iron carbide, Fe_3C ; (3) iron silicide, $FeSi$; (4) iron phosphide, Fe_3P ; (5) manganese carbide, Mn_3C ; and (6) manganese sulphide MnS . The relative proportions of these constituents may readily be calculated from a knowledge of the ultimate composition. Examples are given of the methods of calculating the proximate and structural composition of cast-iron. The formation of spots of white cast-iron surrounded by grey iron receives attention and the mechanism of eutectic, hyper-eutectic, and hypo-eutectic cast-irons is described. With regard to the graphitising of cementite, it is well known that this constituent breaks up into ferrite and graphite on heating to a sufficiently high temperature; that the higher the temperature the more easily does this association take place, and that silicon promotes it. It is probable that the higher the temperature at which cementite forms, the more readily it will be converted into ferrite and graphite on subsequent cooling; and from this assumption it follows that the graphitisation of the cementite in cast-iron during and below

their solidification will take place in the following order with increasing difficulty: (1) graphitisation of pro-eutectic cementite, (2) graphitisation of eutectic cementite, (8) graphitisation of pro-eutectoid cementite, and (4) graphitisation of eutectoid cementite. [See also preceding Abstract.]

C. O. B.

1084. *Influence of High Temperatures on the Physical Properties of Alloys.* I. M. Bregowsky and L. W. Spring. (Eng. News, 69. pp. 872-874, Feb. 20, 1918. Rev. de Métallurgie, 10. pp. 111-128, Jan., 1918.)—The authors have made tests on the mechanical properties in tension and torsion of a large number of commercial metals and alloys of all descriptions (brasses, bronzes, mild steels, alloy steels, cast-iron, etc.) at temperatures up to 1000° F. (588° C.). Heating was effected by means of an electric resistance tube furnace, and the temperatures were measured by inserting a pyrometer into a longitudinal hole bored from the top of the specimen to within a short distance of the test section. The paper is accompanied by 85 diagrams showing the variation of mechanical properties with the temperature, and tables giving the complete chemical analyses of the alloys tested.

F. C. A. H. L.

1085. *Volatilisation of Certain Binary Alloys in High Vacua.* A. J. Berry. (Cambridge Phil. Soc., Proc. 17. 1. pp. 81-88, Feb. 14, 1918.)—The work described in Abstract No. 601 (1912) has been continued with slight modifications in the method employed. Copper and cadmium are separated quantitatively by heating at 600° C. for several hours. An alloy containing Mg with an excess of Cd gave a distillate containing both metals, but no definite relationship was established as regards composition. This pair of metals evidently belongs to Group V. of Groves and Turner's classification [see Abstract No. 1459 (1912)]. Magnesium and lead gave a distillate at 680° C., which consisted chiefly of Mg containing only little Pb. Since the compound Mg₂Pb undoubtedly exists, failure to distil it indicates that it is largely dissociated in the form of vapour.

F. C. A. H. L.

1086. *Some Properties of Industrial Electrolytic Iron.* L. Guillet and A. Portevin. (Comptes Rendus, 156. pp. 702-705, March 8, 1913.)—The electrolytic iron employed had the composition; C, Mn, Si and S—nil; P, 0.025%; As, 0.011%. As prepared, the metal was supersaturated with hydrogen, was brittle, and had a ball hardness of 140, which was reduced to 90 after annealing at 900° C. for 2 hours in magnesia. Determination of the critical points with a Saladin-Le Chatelier galvanometer gave the figures:—

	Heating.		Cooling.	
As prepared	791° C.	987° C.	902° C.	778° C.
After annealing	786° C.	982° C.	902° C.	778° C.

The crude metal shows a critical point between 580° and 690° C. (according to the sample) on heating, but the point is not reproduced on cooling or subsequent reheating. While A₂ is sharp, the point A₁ is a range, particularly on cooling, indicating mutual solubility of α and β iron. The specific resistance of the annealed sample was found to be 9.98 microhms-cm. after correcting for the impurities present. According to Benedicks the true value should be 7.6, showing that the present sample contained 0.008% hydrogen in solid solution.

F. C. A. H. L.

1087. Influence of Arsenic on the Properties of Mild Steel. J. Liedgens. (Elektrotechn. Zeitschr. 84. p. 805, March 6, 1918. Dissertation from the Techn. Hochschule, Berlin, 1912.)—Fourteen alloys, containing 0.1 to 8.8 % As have been prepared from a basic open-hearth steel of the composition ; C, 0.082 ; Mn, 0.487 ; P, 0.020 ; Si, 0.05 ; S, 0.051 ; Cu, 0.174 ; and As 0.084 %, and a complete study has been made of their mechanical and magnetic properties. By autogenous and electrical methods the alloys could be welded up to 1.2 % As, but only up to 0.12 % by ordinary methods. The tensile strength rises to a maximum at 1.6 % As, after which it falls again ; the contraction and extension, however, are diminished continually. Arsenic exerts no apparent influence on the processes of tinning, galvanising, and enamelling. In annealed materials arsenic has no effect on the permeability, hysteresis, remanence, and coercive force, but exerts a beneficial effect on the quenched alloys from the point of view of their magnetic qualities.

F. C. A. H. L.

1088. Why does Lag Increase with the Temperature from which Cooling Starts? H. M. Howe. (Amer. Inst. Mining Engin., Bull. 75. pp. 479-486, March, 1918.)—The transformation of austenite to pearlite plus ferrite or cementite is subject to considerable lag, which increases with the rapidity of cooling, with the presence of retarding elements and with the temperature from which cooling starts. Heating to a high temperature may contribute to the increase of lag in four ways : (1) by increasing the temperature gradient between the shell and core during passage through the transformation range ; (2) by increasing the internal pressure ; (3) by effacing the original crystallisation nuclei ; and (4) by increasing the thoroughness of diffusion and rendering more difficult the subsequent reassembly of the constituents. The author deals with these points at some length, and points out that the causes throwing the interior into compression put the shell into tension and promote the transformation, which accounts for the decreased hardness observed by various workers on increasing the temperature of quenching.

F. C. A. H. L.

1089. Electrical Conductivity and Fluidity of Strong Solutions. W. S. Tucker. (Phys. Soc., Proc. 25. pp. 111-128 ; Discussion, pp. 128-124, Feb. 15, 1918. Electrician, 70. pp. 1182-1184, April 4, 1918. Abstract.)—Experiments were made on the conductivity and viscosity of strong solutions of calcium chloride, both isothermally with varying concentration and over a range of temperature. Smooth curves were obtained even with supercooled melted crystals. By expressing concentration as a ratio of masses (instead of by volume) giving mols. of solute per 100 mols. of solvent, a linear relation was found between the concentration n and the ratio of conductivity to fluidity, for all but the lowest concentrations. This is in agreement with similar observations by Bousfield and Lowry on solutions of sodium hydroxide. The observations at low temperatures are in agreement with those of Kunz in showing a decreased rate of diminution of conductivity, so that marked conductivity still persists at the lowest temperatures.

T. M. L.

1090. Molecular Weight and Turbulence Viscosity. W. Sorkau. (Phys. Zeitschr. 14. pp. 147-152, Feb. 15, 1918.)—The law of viscous flow enunciated by Poiseuille loses its validity when the liquid flows under considerable pressure. The ordinary flow gives way to the turbulent or hydraulic flow first described by Hagen in 1854. For still higher pressures the turbulent

flow is replaced by yet another type of flow resembling the passage of a rigid filament of liquid without viscosity, with the formation of dead water at the capillary wall. The author calls this type "friction-less flow." It obeys the law $t = cVD^{1/2}\rho^{-1/2}$ where D is the density of the liquid and C is a constant determined by the capillary dimensions, but practically independent of the temperature. A comparison of the turbulence viscosities of acetone, ethyl acetate, and chloroform had suggested a connection between these constants and the molecular weights. In order to test this connection, the measurements were extended to the carefully purified esters propyl acetate, butyl acetate, and methyl propionate. The simple formula $C = 12.25 \times M^{1/2}$ was obtained, which recalls Bunsen's law of flow for gases. The succession of speeds of flow for the three acetic esters examined is reversed in proceeding from turbulence to frictionless flow. Knowing that there are two different types of flow, one of them a function of the molecular weight, while the other is a function of the density, this reversal is no longer surprising. That water and alcohol in Hagen's turbulent flow are more viscous than the highly molecular chloroform may be explained by the strong association of these liquids. Some recent experiments indicate an eight-fold molecule for water, similar to that deduced by Duclaux from its expansion. E. E. F.

1091. *Solubility of Active Deposit of Thorium.* C. F. Hogley. (Phil. Mag. 25. pp. 380-382, Feb., 1918.)—A piece of Pt was exposed to thorium emanation for a few days so as to be coated with Th active deposit with the products ThB (10.6 hours) and ThC (1 hour) in equilibrium. The Pt was then dipped into various solutions and the loss of activity measured for the ensuing 4 hours. From the measurements the percentage of either B or C which had dissolved could be determined. It was found that water, solutions of salts, hydroxides, and acids dissolve both products, but ThB is always dissolved in a relatively larger amount than ThC. The results show that the solubility in water (boiling) is small, about 85 % being dissolved in 15 minutes' treatment. A solution of KI was found to dissolve the active deposit at more than twice the rate of water. Dilute HCl or HNO₃ has a much more rapid rate of solution even at ordinary temperatures. In the case of organic solvents the rate of solution was found to be about the same as in the case of water, but the ThC dissolves more easily than the ThB—in fact, ThB is absolutely insoluble in carbon disulphide and methylene iodide, whilst ThC is soluble to the extent of 20 % in 10 minutes. E. M.

1092. *Alteration of the Vapour Pressures of Aqueous Sulphuric Acid Solutions with the Temperature.* C. Hacker. (Ann. d. Physik, 89. 6. pp. 1888-1849, Dec. 28, 1912. Extract from Inaug. Dissertation, Kiel, 1912.)—Von Babo's law, which states that the ratio between the vapour pressures of an aqueous solution, p_s , and of pure water, p_w , is independent of the temperature and depends only on the concentration of the solution, is not in agreement with the requirements of thermodynamics and would, indeed, lead to the conclusion that the heat of dilution would be zero for all solutions. Since attempts to detect divergences from this law by direct measurement have given no certain results, the author has made observations on the differences between the vapour pressures of various sulphuric acid solutions and those of pure water at temperatures from 0° to 100°. The results show that von Babo's law is invalid and that the divergences from it increase with the concentration, as is required by the theory of the heat of dilution. The numbers obtained for the vapour pressures are also found to agree quantitatively with the observed heats of dilution. T. H. P.

1093. Laws of Corresponding States. E. H. Amagat. (Comptes Rendus, 156. pp. 271-277, Jan. 27, 1918.)—Various investigations have indicated that, for different substances, the expression, $E = pv/T$, has identical values at corresponding points, provided the volumes are referred to the molecular weights. This relation apparently holds for normal substances and discordant results are attributed to the influence of secondary factors, such as polymerisation. This conclusion is supported by the fact that, of 28 compounds examined, those of similar type give equal values of E in all cases excepting with the alcohols, which exhibit a tendency to polymerise. Criticisms made by Mathias (Congrès du Froid, 1912) are answered. T. H. P.

1094. Saturation Curves and the Law of Corresponding States. E. H. Amagat. (Comptes Rendus, 156. pp. 848-848, March 17, 1918.)—The author has shown previously [see preceding Abstract] that the saturation curves constructed with reduced pressures as abscissæ and the values of pv/T as ordinates—which should be coincident if the law of corresponding states were rigorously obeyed—lie within a comparatively narrow strip, showing that the deviations from the law are much smaller than has been usually thought. Further consideration of the curves and of saturation curves for other compounds, as well as of the curves connecting p and pv , leads the author to regard the law of corresponding states not merely as an approximation but as a fundamental scientific law. T. H. P.

1095. The Law of Guldberg and Corresponding States. A. Leduc. (Comptes Rendus, 156. pp. 65-66, Jan. 6, 1918.)—In discussing the relationship between the critical coefficient and molecular weight of a substance Boutaric [see Abstract No. 787 (1918)] had assumed that the boiling-points of different liquids under normal pressures were corresponding, although he knew that this assumption was not quite justified. The author suggests that the following modification of Guldberg's law would be justified: The boiling-points of substances under equally reduced pressures are corresponding temperatures. If the pressure is reduced to $1/76$ of what it is at the critical temperature, *i.e.* to as many cm. as there are atmospheres, the quotient T/θ is approximately 0.6 for acids, ethyl-chloride, etc. (though only about 0.55 for N, O, CH₄, etc.) but greater than 0.6 for alcohols, water, and CO₂. H. B.

1096. Method of determining "a" of van der Waals' Equation from the Surface Tension. A. P. Mathews. (Journ. Phys. Chem. 17. pp. 154-161, Feb., 1918.)—Uncertainty still exists as to the correct value of van der Waals' constant a , which expresses the cohesive pressure of a fluid. The author's method of calculating it is based on the surface-tension formula of Young and Eötvös, $S = rK/8$ (where r is the radius of action of the cohesive attraction and K the total cohesive pressure), Rayleigh's formula $S = 8rK/20$, leading to obviously improbable values of a ; further, the method, unlike those previously used, is independent of any assumption as to the value of b or of its constancy when pressure and temperature are changed. The constant a may be equated to N^2M^2K , where N is the number of molecules in the volume V , so that, if V^2 be written N^2v^2 , $a/V^2 = M^2K/v^2$, where v is the volume at the disposal of a single molecule. M may be called the mass of cohesion of a molecule and K a constant of proportion. At the temperature absolute zero, when the molecules are in contact, $r = v^{1/3}$, so that $S \cdot v^{1/3} = KM^2/2v_0$. Further, according to Eötvös' formula, $S \cdot v^{1/3} = 2.19 (T_c - \theta)/N^{1/3}$. Hence, assuming the value 6.21×10^{22} for N , $M^2K = 9.045 \times 10^{-16} (T_c - \theta)v_0$. From the values of M^2K thus obtained, those of a and b are readily calculable. For ether, VOL. XVI.—A.—1918.

pentane, and isopentane, which are non-associating substances and have been very carefully investigated, the ratio $V_c : b_c$ has the values 2.078, 2.074 and 2.072 respectively. The mean of these, 2.074, agrees closely with that calculated in various ways by van der Waals, and differs considerably from the theoretical number, 8. The equations expressing the relations between these constants and the critical constants hence require modification. Thus, $a/P_c = 8V_c^3$ becomes $a/P_c = 6.284 V_c^3$; $P_c = a/27.02 b_c^3$ and not $a/27 b_c^3$; $T_c = 7.769 a/27.02 R b_c$, not $8a/27 R b_c$, etc.

In most cases the values of M^2K calculated from the surface-tension formula agree moderately well with those given by the ordinary formula, but a few appreciable differences occur, and it seems probable that the former are the more accurate.

T. H. P.

1097. *New Method for determining the Diffusion of Dissolved Substances.* L. W. Öholm. (K. Vetenskapsakad. Nobel Inst. 2. No. 22, pp. 1-28, 1912.)—The diffusion apparatus devised by the author consists of four round slabs, which are superposed so that their central holes, 2 cm. in diam., exactly correspond; of a plain lid and a bottom slab having a central capillary nozzle connected by means of a clipped rubber tube with a pipette containing the diffusing solution. All the slabs and the lid are of brass and are ground quite smooth. The five slabs are greased and are then wiped with a fine linen cloth so that sufficient grease remains on them to ensure that the solution does not cling. The diffusing liquid is run carefully down the rubber tube so as to expel all the air and so that the capillary hole in the bottom slab is just reached. Three of the slabs are then fitted and the hollow cylinder thus formed filled with the solvent, say water, a slight excess of which rests on the top of the third slab; this excess is swept off by putting on the fourth slab, the liquid column left thus having exactly the same height as the three slabs. This column is then raised through the height of one layer by running in from the pipette, an amount of the diffusing liquid just corresponding with one layer; the extra 1 mm. thickness of the top slab is left free. Evaporation is prevented by means of the lid. The apparatus is especially useful for viscous solutions, such as aqueous glycerine solutions of lithium or potassium chloride, which would adhere too strongly to glass. Test experiments with potassium chloride solutions show that the apparatus gives reliable results.

The resistance of potassium chloride to diffusion is increased considerably by the addition of a non-electrolyte to the solution. Thus, a solution of the salt in water gives at 18° the diffusion coefficient 1.819-1.880, the value in 1.5N-sucrose solution being 0.410-0.420; in 2N-sucrose solution 0.215-0.242; and in 7.48N-glycerol solution, 0.174-0.176.

T. H. P.

1098. *Diffusion of an Electrolyte in Gelatine.* L. W. Öholm. (K. Vetenskapsakad. Nobel Inst. 2. No. 80, pp. 1-8, 1912.)—The author has measured the electrical conductivity of solutions of potassium chloride containing various proportions of gelatine, and has also determined the diffusion coefficients for the same solutions by means of the apparatus already described [see preceding Abstract]. The results show that the electrical conductivity as well as the diffusion are appreciably less in a solution of gelatine than in pure water, the decrease being about 6 % for a 2 % gelatine solution; the degree of dissociation of the electrolyte is not, however, changed. Further, the extents to which the diffusion coefficient and the conductivity are diminished are equal for equal contents of gelatine. The

curve showing the relation between the diffusion coefficients and the proportions of gelatine present is of the same form as the corresponding curve for potassium chloride solutions containing sucrose or glycerol, so that, as a first approximation at least, a gelatinous body affects the diffusion and the conductivity of an electrolyte in exactly the same way as a non-electrolyte in general.

T. H. P.

1099. *Diffusion of Silver into Glass.* G. Schulze. (Ann. d. Physik, 40. 2. pp. 385-387, Feb. 4, 1913. Communication from the Physikal.-Techn. Reichsanstalt.)—The diffusion of silver from fused silver nitrate was noticed by Heydweiller and Kopfermann [see Abstract No. 1374 (1910).] The experiments were made with glass tubes, open at both ends, or test-tubes, dipped into fused AgNO_3 , or containing mixtures of K and Na nitrates; the nitrates were electrically heated. The glass is described as a Thuringian glass containing 11 per cent. of Na; but there is some mistake in the percentages given. Above 250°C . silver diffuses into the glass from the nitrate in the form of free ions, sodium ions leaving the glass. The conductivity is apparently lowered because the glass resistance rises when the glass is heated for long periods; but there is really an increase in conductivity produced by the replacement of Na by Ag. The diffusion follows the law of Warburg, the amount of silver entering being proportional to the square root of the time and to the square root of the product of the conductivity of the glass and its absolute temperature. The concentration of the silver decreases as the depth increases. Electrolysis introduces the silver more rapidly, and experiments were made with electrolysis and diffusion acting in the same and in different directions. The measurements are difficult, because the tubes always crack, and because the glass is chemically attacked by the liberated alkali: to avoid the latter effect, the test-tubes were filled with KHSO_4 or, better, with H_2SiO_3 . Glass charged with silver appears like gold or silver in reflected light and bluish-green in transmitted light, when heated in the Bunsen flame. A formula is also given for the diffusion of silver into glass from the mixed fused nitrates of Ag and Na. E. Warburg. (Ibid. 40. 2. pp. 327-384, Feb. 4, 1913.)—Warburg assumes that both in electrolysis and in diffusion the positive ions alone migrate; their velocity might be calculated after Nernst, but the diffused electrolyte is not completely dissociated, and he supposes that each molecule will be dissociated and not dissociated for different periods. The theory deduced is in the main in agreement with the experiments; but it differs as to the concentration of the silver at considerable depth of the glass and as to the concentration of the silver diffusing into the glass from mixtures of silver and sodium nitrates.

H. B.

1100. *Dependence of Diffusion on the Viscosity of the Solvent.* L. W. Öholm. (K. Vetenskapsakad. Nobel Inst. 2. No. 26. pp. 1-21, 1912.)—From Einstein's molecular kinetic equation of diffusion [see Abstract No. 1122 (1908)] it follows that the diffusion coefficients of one and the same non-electrolyte in different solvents and under otherwise similar conditions should be inversely proportional to the viscosities of the solvents, that is $k\eta = \text{const}$. The empirical square-root equation, $k\sqrt{M} = C$, leads to the same conclusion. In both cases the solutions are assumed to be very dilute, so that the viscosity of the solute plays no great part, and, further, the Einstein formula supposes the molecules of the solute to be large in comparison with those of the solvent. The author has investigated the viscosity and diffusion of solutions of glycerol and bromoform, the solvents, with viscosities varying from 0.25 to 4.45, being

ether, benzene, acetone and ethyl, methyl, propyl and amyl alcohols. The percentage increases in viscosity produced by solution of glycerol to N-concentration are as follows: Water, 27.5; ethyl alcohol, 47.5; 50 per cent. ethyl alcohol, 21.1; propyl alcohol, 51.2; amyl alcohol, 54.1. These increases are very irregular and bear no simple proportion to the viscosities of the solvents themselves. But with the alcohols, the absolute increases in viscosity are about proportional to the viscosities themselves, although 50 % ethyl alcohol gives approximately the same increase as pure alcohol with less than one-half its viscosity. In the influence of bromoform on the viscosity there is greater regularity: the smaller the viscosity of the solvent itself, the greater is the percentage increase of the viscosity on addition of bromoform. The percentage increases for N-concentration of the solute are: Ether, 35; acetone, 24; methyl alcohol, 17; benzene, 18; ethyl alcohol, 9; propyl alcohol, 1.4; amyl alcohol, —9.8. As the viscosities of the solutions, in comparison with those of the components, indicate an additive relation, the bromoform probably occurs in these as single free molecules and does not influence the association factors of the various solvents. The results of the diffusion measurements indicate that neither with glycerol nor with bromoform does $k\eta$ remain constant with different solvents. The solutions used were certainly fairly concentrated, but the numerical results do not seem to indicate constant limiting values. The various factors disregarded by the Einstein formula are discussed.

T. H. P.

1101. *Condensation of Water-vapour in Presence of Nitrogen Oxides and Hydrogen Peroxide, etc.* W. Bieber. (Ann. d. Physik, 89. 6. pp. 1818–1887, Dec. 28, 1912. From Dissertation, Marburg, April 29, 1911 and Marburg Naturforschenden Gesell., Dec., 1911.)—In connection with the action of oxides of nitrogen in inducing the condensation of water-vapour [see Pringal, Abstract No. 2045 (1908)], the author has made experiments which show that stable ozone, even under the influence of light, is not able to oxidise free nitrogen. According to Barkow [see Abstract No. 1477 (1907)] and to Pringal, the formation of a blue fog depends on the production of oxides of nitrogen, but the author finds that this may occur in oxygen free from nitrogen. The experiments also confirm Wilson's view [see Abstract No. 1025 (1900)] that hydrogen peroxide exists in solution in the blue fog. The possible modes of formation of the peroxide are discussed. Atmospheric hydrogen peroxide undoubtedly owes its existence largely to the action of ultra-violet rays, which liberate oxygen atoms; the latter not only give the peroxide, but also oxidise the ammonia of the air first to hydroxylamine and subsequently to ammonium nitrite. The blue colour of the sky is regarded as due to the presence, in the upper strata of the atmosphere, of small solid particles of ammonium nitrite or nitrate, which scatter the more highly refractive rays to a greater degree than the others; the cause of the variations in the tint must be sought in the varying turbidity of the lower layers of the atmosphere. That such particles do not continually increase in number is due to the establishment of an equilibrium.

T. H. P.

1102. *Electrical Conductance of Non-aqueous Solutions.* L. I. Shaw. (Journ. Phys. Chem. 17. pp. 162–176, Feb., 1918.)—Walden's investigation of solutions of tetraethyl-ammonium iodide in a number of organic solvents of different chemical types showed that the dissociating power of the solvent increases with its dielectric constant. In order to ascertain if other solutes

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act in an analogous manner to the above iodide, the author has examined qualitatively the conductivity of a number of inorganic salts in methyl alcohol, salicylaldehyde, benzaldehyde, acetic anhydride, acetyl chloride, ethyl acetate, dimethyl sulphate, benzonitrile, acetone, aniline and epichlorhydrin. Among other results it is found no relation is evident between the dissociating power of a solvent and its dielectric constant, extent of association or its chemical unsaturation. Quantitative conductivity measurements were made on solutions of mercuric chloride and iodine in epichlorhydrin and of mercuric and lithium chlorides and iodine in acetone. In none of these cases does the molecular conductivity exhibit a limiting value on dilution, but increases steadily even at very high dilutions. Consequently the degree of dissociation at any given dilution cannot be found by dividing the conductivity at that dilution by the conductivity at infinite dilution. With a solution of lithium chloride in acetone, the molecular conductivity at first increases, then decreases and finally increases again with progressive dilution. The fact that the author has prepared epichlorhydrin and acetone with conductivities lower than the minimum values attainable by Walden seems to indicate that these solvents conduct, not by reason of "self-dissociation" but owing to the presence of constant impurities.

T. H. P.

1103. *Electrical and Chemical Effects of the Explosion of Azoimide.* P. J. Kirkby and J. E. Marsh. (Roy. Soc., Proc. Ser. A. 88. pp. 90-99, Feb. 24, 1918.)—The HN_3 is prepared by letting sulphuric acid decompose BaN_3 , and by sucking the dried HN_3 into a receiver and an explosion chamber, the annular space between two gilded brass cylinders, one of which is joined to one of the Oxford electric mains (about 105 volts), and the other to a low-resistance ballistic galvanometer (d'Arsonval); the Pt-wires for exploding the gas are inserted in the tubular connection of the chamber with the glass apparatus. The explosion chamber is exhausted; the gas is then admitted and exploded, and the throw of the galvanometer determined; "a series of experiments is carried out continuously upon the same sample of gas." The number of pairs of ions generated by an explosion of azoimide, it is said, is exceedingly small (less than 1 in 100,000) compared with the number of molecules dissociated by the explosion. The numbers were irregular, however, one of the explosions (sometimes the first, sometimes another of a series) giving many times (7) more electricity than another; the results varied also when the polarity of the two cylinders was exchanged or resistance introduced into the circuit. The lowest gas pressure observed at which explosion took place was 11 mm., whilst in previous experiments with electrolytic gas [see Abstract No. 8258 (1904)] the minimum was 80 mm. The brass cylinders had been gilded to prevent action of the azoimide on the copper; yet a small amount of a crystalline deposit, apparently of cupric azoimide, was observed at the end of a series; this cupric azoimide is supposed to have been formed during the actual explosions, not before them.

H. B.

1104. *Charged Surface Layers in Contact-Potential Phenomena between Metals.* A. N. Shaw. (Phil. Mag. 25. pp. 241-256, Feb., 1918. Electrician, 71. pp. 25-26, April 11, 1918. Abstract.)—The author describes ionisation methods for measuring contact potentials between metallic plates, and shows that they give reliable results. Investigation of the rate of charging due to contact potential in the case of an insulated plate in ionised gas leads to new direct evidence of the presence of charged surface layers. The time necessary for the formation and charge of these layers is found to be measur-

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able, and effects due to their capacity are detectable. Their behaviour agrees with the conception that contact-potential phenomena can be explained by the different amounts of work done by electrons in escaping from different metals. The rate of charging or removal of the layers responsible for contact potential is shown to be independent apparently of the metal and identical with the behaviour of ordinary charges imparted by external means. The influence of the dryness of the gaseous medium and the nature of the gas on the formation of these charged layers has been investigated, and it would appear that, although chemical action may cause large contact effects, it is not usually responsible for more than a small part of the phenomenon.

T. H. P.

1105. Ionisation and the Law of Mass Action. W. R. Bousfield. (Chem. Soc., Journ. 108. pp. 807-817, Feb., 1918.)—At very great dilutions the coefficient of ionisation of a dissolved salt becomes substantially equal to unity. There is therefore, then, no real difference between any of the following five dilution formulæ :—

Rudolphi	$\frac{a^2}{1-a} = \frac{h^2}{5.87}$	New relation	$\frac{a}{1-a} = \frac{h^2}{5.87}$
Van't Hoff.....	$\frac{a^2}{1-a} = \frac{h^2}{5.87}$	Kohlrausch.....	$\frac{a^n}{1-a} = \frac{h^2}{5.87}$
Limiting relation.....	$\frac{1}{1-a} = \frac{h^2}{5.87}$		

where h is the number of mols. of water per mol. of solute. All of these may be applied equally well to interpret the conductivity data for potassium chloride, but all agree in giving the coefficient 0.5 to h at infinite dilution. They may therefore all be reduced to the simple formula $(1-a) = h^{-1} \times \text{const.}$ whilst in the same region of great dilution Ostwald's Mass-action Law reduces to $(1-a) = h^{-1} \times \text{const.}$ These two formulæ bring out the fundamental difference between the class of "weak" electrolytes, of which acetic acid is an example, and the class of "strong" electrolytes, of which potassium chloride is an example, since for *weak* electrolytes the active mass of the undissociated fraction at great dilution is inversely proportional to the *mass* of the water; for *strong* electrolytes the active mass of the undissociated fraction at great dilution is inversely proportional to the *square root of the mass* of the water.

T. M. L.

1106. Mechanism of the Chlorination of Benzene in the Electrolytic Cell. R. G. Van Name and C. H. Maryott. (Amer. Journ. Sci. 85. pp. 158-170, Feb., 1918.)—Chlorinations may take place in two ways: by an electrolytic process which is confined to the surface of the anode, and by the secondary action of the dissolved chlorine gas previously liberated by the current. Referring to Zehrlant and to Schleuderberg [see Abstracts Nos. 1157 (1901) and 192 (1909)] the author obtained no positive evidence of any strictly electrolytic chlorination when electrolysing benzene dissolved in glacial acetic acid to which lithium chloride had been added, though the yields rose to 70 per cent.; the direct treatment of the solution with chlorine gas in the dark directly yielded addition and substitution products as before; this reaction was not accelerated by simultaneous electrolysis. The addition of benzene to the solvent mentioned raised the anode potential like an addition of carbon-tetrachloride, whilst phenol lowered the potential.

H. B.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1918.

GENERAL PHYSICS.

1107. *Measuring the Flight of Balloons and Flying Machines.* **L. Ambrohn.** (Zeitschr. Instrumentenk. 88. pp. 106–107, April, 1918.)—Describes a new instrument for determining the flight of air-craft. The lower part of the apparatus is similar to a theodolite base, and carries a telescope arrangement of special form. The telescope is arranged to look at one of the faces of a total-reflection right-angled prism which is movable about a horizontal axis, and whose position can be noted on a circular scale. A magnetic needle is provided, and special arrangements enable the observer easily to determine the magnetic azimuth, as well as the altitude of the object under observation. A. W.

1108. *Elasticity of Crystals.* **T. Reimers.** (Phys. Zeitschr. 14. pp. 276–278, April 1, 1918.)—According to Voigt (1892), a crystalline rod or cylinder of doubly symmetrical section, when bent, does not undergo a pure flexure, but is also twisted. The author tested this by direct experiment on a rod cut from a gypsum crystal, fixed at one end and loaded at the other by two 1-gm. weights connected by a cocoon fibre lying across the rod. The torsion was observed by means of a small mirror attached to the rod. It was found to be in agreement with Voigt's formula. E. E. F.

1109. *Theory of Elasticity.* **T. v. Kármán.** (Phys. Zeitschr. 14. pp. 258–254, March 15, 1918.)—Maintains, with reference to a paper by H. Lorenz [Abstract No. 540 (1918)], that the theorem according to which “the difference between the internal and double the external work has a singular value in the case of elastic equilibrium” is identical with the principle of minimum potential energy applied to the case of a body obeying Hooke's law. Neither Ritz's method nor Castigliano's theorem need be brought in. **H. Lorenz.** (Ibid. p. 254, March 15, 1918.)—Lorenz replies to the above, agreeing with the derivation of the theorem, but doubting its utility. E. E. F.

1110. *Stress Distribution in Notched Tension Bars.* **E. Preuss.** (Zeitschr. Vereines Deutsch. Ing. 57. pp. 664–667, April 26, 1918.)—The test-pieces were
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all 75 mm. wide, the load being applied through bolts, 480 mm. apart. A notch was cut at each end of the middle cross-section, various forms being tried. Axial and lateral strains were measured, the principal stresses across the middle section being deduced with the aid of the modulus of elasticity and Poisson's ratio. The axial stresses are shown plotted, and reach sharp maxima at the edges of the notches. For the same depth of notch the max. stress is greater the smaller the radius or base. For constant radius and breadth the max. stress increases with the depth. For semi-circular notches the max. stress increases as the radius diminishes. Neglecting sharp triangular notches, maxima of 1.48 to 2.48 times mean were observed with dimensions each way varying from 5 mm. to 15 mm. The minimum stress at the centre varied from 0.71 to 0.98 of the mean. The stress-distribution is most even over a greater part of the width for wide, shallow notches. It is suggested that the numerical results obtained can be used, *e.g.* to determine the max. bending stress in a shaft at a change of section. The ordinary value of stress $f = MZ$ is replaced by $f = CMZ$, where C is a suitable constant, > 1 .
E. J. S.

1111. *Tests of Three Struts from a Collapsed Gasholder in Hamburg.* H. Rudeloff. (Zeitschr. Vereines Deutsch. Ing. 57. pp. 615-620, April 19, 1918.)—The struts were each made up of two steel channels 8290 mm. long, placed back to back, with 26 mm. clear between the webs, a compressive load being applied through 65-mm. balls whose centres were 8465 mm. apart. Lateral movements were detected in two planes at right angles by Bauschinger roller apparatus. Two of the struts exhibited a distinct displacement in the plane of the greatest radius of gyration as well as in that of the least. The increase of bending with load was very uniform, and photographs after crippling show that the member on the tension side is in all cases bent sharply outwards, and the other inwards. It follows that the strength would be increased by placing the channels farther apart. Four Martens mirror extensometers were used to measure the strains on each flange. Although owing to flexure the strains varied greatly from the mean, and the variations were different in the three struts, yet the three means at any given load corresponded remarkably well. This shows that in no case was the metal overstrained at the highest load at which strain measurements were made. Above 40,000 kg. the rate of increase of the mean strain fell off owing to the compressive strains on the tension side changing rapidly to tensile as flexure increased, although on the compressive side they continue to rise faster than the load. The total compressive stress on the strut can, therefore, only be deduced from the mean compressive strain so long as the material is nowhere elastically overstrained. The crippling load is found to be smaller than that given by the usual theorems, the relative values being: Euler 0.76, Tetmayer 0.92. The theory of Müller-Breslau, based on the theory of bending by an eccentric load, all parts being assumed elastic, gives the value 1.006.

E. J. S.

1112. *Hardening Tests.* G. Charpy. (Rev. de Métallurgie, 10. pp. 898-899, March, 1918.)—Hardening tests are sometimes specified with a view to determining the utility of a material for a certain purpose (*e.g.* steel for boiler-plates) or to determining whether a material is susceptible to heat treatment. The author discusses the various factors which influence the results of such tests, and points out the necessity that they should be made under definite conditions.

F. C. A. H. L.

1113. Elastic Limit of Alloys. **A. Portevin.** (Comptes Rendus, 156. pp. 1287-1240, April 21, 1918.)—Experiments have been made on the deformation of pyramidal test-pieces (Fremont method) in order to determine if the elastic limit can be observed microscopically by the appearance of slip bands. In a chemically homogeneous solid solution slip bands first appear in certain grains and gradually extend to the whole of them. By this means it is possible to determine the lower and upper limits of elasticity. In a heterogeneous single solid solution the slip bands first appear in the centre of the grains and do not extend to the edges until higher loads are reached. The result is that the boundaries of the grains are not developed. An alloy consisting of two phases generally develops slip bands only in the α -phase. As a result, therefore, of the mechanical anisotropy of the grains and the chemical heterogeneity of the alloy, the slip bands do not appear simultaneously in all parts of the alloy. Consequently a definite value cannot be ascribed to the elastic limit.

F. C. A. H. L.

1114. Viscosity of Gases. **H. Piwnikiewicz.** (Phys. Zeitschr. 14. pp. 805-808, April 1, 1918.)—A simplified apparatus is described, consisting of two tubes communicating by a capillary tube 0.4 mm. in internal diam. and 40 cm. long. The gas is expelled from one vessel to the other by mercury against the viscous resistance. A set of glass taps enables one to reverse the current of gas, so that the same gas can be used again. Therein the apparatus differs from that of J. H. T. Roberts [Abstract No. 778 (1912)].

E. E. F.

1115. Simple Method for determining the Viscosity of Air. **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 17. pp. 188-192, April, 1918.)—Air is pumped into a vessel of about 10 litres' capacity until a pressure of 20-25 cm. Hg above the atmosphere is reached, and is then allowed to escape through a capillary tube some 60 or 70 cm. long. The pressure of the air at the beginning and end of a measured interval of time is determined, and from the fall in pressure the volume of air passing is deduced. The viscosity η of the air, in dynes per sq. cm. per unit velocity gradient, is calculated from the formula $\eta = \pi a^4 P_0 / 8 l S \cdot t / \lambda$, where a is the radius of the tube, l its length, P_0 the atmospheric pressure, S the volume of the vessel, t the time, and $\lambda = \log_e [(P_1 - P_0)/(P_2 - P_0) \cdot (P_2 + P_0)/(P_1 + P_0)]$ where P_1 and P_2 are the pressures at the beginning and end of the interval t . The temperature in the apparatus is considered equal to that of the surrounding atmosphere throughout the experiment. When the flow tube is not of uniform bore, it is necessary to apply a correction, the method for calculating which is given. The mean value obtained for the viscosity of air at 18.6° C. is 1.80×10^{-4} gm. cm.⁻¹ sec.⁻¹.

W. H. St.

1116. Advance of Alternate Vortices in the Rear of an Obstacle. **H. Bénard.** (Comptes Rendus, 156. pp. 1225-1228, April 21, 1918.)—In a preceding note [Abstract No. 911 (1918)] the author has localised the zone of formation of alternate vortices. At first the vortices have the same speed as the moving obstacle, but quickly slacken, at the same time diverging to the right and left. They quickly attain their transversal limit, longitudinal equidistance, and limiting speed, which are preserved if the vortices are not too much deadened. When old they are more and more sensible to accidental fluctuations, while the equidistance in particular is less and less well defined. The present paper is a further kinematographic study of the question, numerical data being obtained.

H. H. Ho.

1117. *New Species of Cellular Vortices.* C. Dautère. (Comptes Rendus, 156. pp. 218-220, Jan. 20, and pp. 1228-1230, April 21, 1918.)—H. Bénard's work [see preceding Abstract] is briefly referred to, dealing with experiments upon detached vortices. The formation of these is explained by the existence of an extremely thin film covering the regions free from partitions. The case of impure stearic acid such as is found in candles is described, this being coloured rose or blue. The superficial film is formed by very fine grains of colouring matter covering the whole surface, so that isolated vortices are no longer formed. Thermal convection gives rise beneath the film to elongated vortices analogous to some observed by Bénard. The free surface is formed of longitudinal furrows comprising parallel and equidistant crests and troughs, relieved at certain points by transverse division, which sometimes gives an hexagonal cellular network, often, however, only in a state of outline. In consequence of this relief there is the formation of distinct focal lines when observed by refracted light. The description is illustrated by four photographs. The experiments were performed at rising and falling temperatures, results for varying thicknesses of liquid being given.

H. H. Ho.

1118. *Co-ordinate Systems of Dynamics.* E. Gehrcke. (Deutsch. Phys. Gesell., Verh. 15. 7. pp. 260-266, April 15, 1918.)—Discusses the co-ordinate systems from the standpoint of the classical mechanics and the modern theory of relativity.

E. H. B.

1119. *Minkowski's Mechanics.* F. J. de Wisniewski. (Ann. d. Physik, 40. 4. pp. 668-676, April 15, 1918.)—The second part of a mathematical treatment. [See Abstract No. 768 (1918).]

E. H. B.

1120. *Measurement of the True Static Pressure in a Moving Fluid Application to an Aeroplane Barograph.* A. F. Zahm. (Frank. Inst., Journ. 175. pp. 508-509, May, 1918.)—Briefly discusses the errors of a barograph carried on an aeroplane caused by the rush of air past the instrument case.

L. H. W.

1121. *Hurricanes of the West Indies.* O. L. Fassig. (U.S. Department of Agriculture, Weather Bureau, Bull. 10. pp. 7-28, March, 1918.)—In addition to a detailed discussion of the West Indian hurricanes the paper deals with the cyclones of the Bay of Bengal and the typhoons of the Western Pacific, these all being of the same type of revolving storm. In 1899 a chain of cable reporting stations was established along the margin of the hurricane region, and all well-developed storms occurring within the area have since been carefully reported and charted from day to day. A detailed account is given of the movements of a destructive storm which passed over the district during the period Aug. 7-20, 1899. The pressure recorded in the centre of this hurricane was 27.75 in. In tropical storms, in general there is a moderate decrease of pressure to within 40 or 50 miles of the centre and then the rapid fall which is associated with the destructive winds. 90 % of all the hurricanes recorded have their origin within a belt extending from 58° to 90° W. longitude and from 12° to 26° N. latitude. The normal track for the entire season, determined from 185 storm paths, extends in a W. by N. direction between 18° and 20° N. to the centre of the hurricane area (20° N., 78° W.) then NW. and N., recurving over central Florida. The trend is then NE.

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over the North Atlantic. The normal track differs from month to month. Its movements coincide very closely with those of the trades and equatorial belt of calms. The hurricane season is of short duration, 88 % of all hurricanes occurring in the period Aug.-Oct. The mean rate of travel of these storms is 800 miles per day, or less than half the speed of the temperate-region cyclone of the United States. The average duration of a hurricane is 6 days. The signs of an approaching storm are discussed in detail, the most important and earliest sign being the cirrus cloud.

J. S. DI.

1122. On the Occurrence of Line Squalls in relation to the March of the Barometer at a Place. Durand-Gréville. (Comptes Rendus, 156. pp. 1190-1198, April 14, 1918.)—A barogram obtained at any station may be constructed from the corresponding isobaric map by drawing a section through the station across the map, parallel to the direction of propagation of the isobaric distribution, if it is assumed that the form and intensity of the distribution does not change. By considering sections across a typical depression with a *ruban de grain* (line squall) arranged along a radius on its southern side, it is shown that the form and position of the *crochet barometrique*, indicated on the barogram as representing the pressure-increase connected with the squall, depends at each instant upon the angle which the direction of the *ruban* makes with the direction of motion of the centre of the depression.

R. C.

1123. Relation between Atmospheric Absorption and Polarisation of Light diffused by the Sky. A. Boutaric. (Comptes Rendus, 156. pp. 1289-1292, April 21, 1918.)—Observations at Montpellier, made as frequently as the state of the sky permitted, of (1) the proportion of polarised light contained in the light diffused by the sky, and (2) heat radiation at different times of the day, measured by an Ångström pyrheliometer, lead to the conclusion that for the greater part of the radiation from the sun, the absorption by the atmosphere varies inversely with the proportion of polarised light.

R. C.

LIGHT.

1124. *Soleil-Babinet Compensator with Half-shadow Arrangement.* G. Sziwessy. (Deutsch. Phys. Gesell., Verh. 15. 6. pp. 201-209, March 30, 1918.)—Describes, and also gives theory of, a half-shadow compensator which consists of an ordinary Soleil-Babinet compensator provided with a half-shadow plate. The arrangement permits of considerably increased accuracy of adjustment. A sensitive modification is obtained as follows:—The half-shadow plate is fixed, the optic axes of the two halves H_1H_2 being parallel to the face of the plate and respectively parallel and perpendicular to the line of separation of the two halves. The fixed wedge and also the movable one are similarly divided: the halves $W_1W'_1$, through which the light passes after going through H_1 , have their optic axes parallel to the face of the half-shadow plate and perpendicular to the line of separation; in the other halves $W_2W'_2$ the axes are parallel to the line of separation. A. W.

1125. *New Microscope Eyepieces.* Metz. (Zeitschr. wiss. Mikroskopie, 29. p. 72. Nature, 91. pp. 59-61, March 20, 1918.)—The author has recently described a micrometer in which the scale used is such that microns can at once be read off without greatly changing the tube-length, or considering the micrometer value of the objective employed. The intervals of the new scale, instead of being $1/10$ or $1/20$ mm. wide, as is usually the case in eyepiece micrometers, have a definite value of 0.06 mm. With a 2-mm. ($\frac{1}{4}$ in.) objective, when a stage micrometer with ten $1/100$ mm. divisions is viewed, each of these divisions falls on the larger divisions of the eyepiece micrometer. Each of the smaller divisions therefore represents a micron. With a 4-mm. ($\frac{1}{2}$ in.) objective the ten divisions of the stage micrometer cover five of the large divisions of the eyepiece micrometer; hence to obtain microns we must multiply by 2, and this is all the arithmetic needed. In the new micrometer the intervals are arranged in groups or steps of ten, each group being indicated by a black echelon rising from the first to the tenth interval, thus making it easy to read. The apparatus is made by Leitz. Another form of eyepiece, also introduced by Leitz, enables two observers to use the same objective. It is called a double demonstrating eyepiece, since it is designed for demonstrating purposes. The field of view is common to both eyepieces, and contains a pointer which either observer can direct upon any feature to which he wishes to direct attention. A sketch of the apparatus is given. A. W.

1126. *New Mounting for Microscope Preparations.* C. Cépède. (Comptes Rendus, 156. pp. 688-685, March 8, 1918.)—Describes a new method of mounting microscope preparations, which allows both faces of the object to be studied at the highest magnifications. Ordinary plates are perforated with a circular hole in the central part 19 mm. diam. The lower edge of the hole is slightly countersunk, and the upper edge is countersunk so as to leave a ledge, the diam. of the countersunk part being 28 mm. A cover-glass 22 mm. diam. is secured in the recess, the object mounted on it in balsam or gelatine, and another cover-glass pressed lightly on the top. The balsam or gelatine serves as a cement to unite the cover-glasses to the plate, which is dried in the ordinary way. One advantage of this method of mounting is that a

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number of such plates can be packed in contact, with no risk of damaging special specimens by the pressure of one plate against another, since a considerable space separates the face of the cover-slips from the face of the plate.

A. W.

1127. *Imprisonment of Radiation by Total Reflection.* R. W. Wood. (Phil. Mag. 25. pp. 449-452, April, 1918. Phys. Zeitschr. 14. pp. 270-272, April 1, 1918.)—In working with his rhodamine fluorescent reflectors for the mercury arc, P. Cooper Hewitt found that if the celluloid film stained with rhodamine was backed by white paper the fluorescence was many times brighter than when a backing of silver paper was used. This result has been verified by Wood by depositing silver chemically over a very small circular area in the centre of a white porcelain plate, and flowing the whole with the rhodamine solution, or with water containing a little fluorescein. Notwithstanding the very high reflecting power of the polished silver film, the intensity of the fluorescence over the circular area was so feeble that it appeared almost black in contrast with the brilliant fluorescence over the surface of the porcelain. The plate was illuminated with the mercury arc in the case of the rhodamine, or with the light of the carbon arc, passed through dense cobalt glass, in the case of the fluorescein. It was noticed that the films which had been stripped from the surface glowed brilliantly along the edges, this being due to the circumstance that more radiation was able to escape here than through an equal area of the surface of the film. The action of the matt surface is to liberate the energy imprisoned by internal reflection. Mendenhall has found that with a scratch on the surface of a ball of fused quartz, heated in a Bunsen burner, the black-body temperature of the scratch, as observed with an optical pyrometer, was 850° C., while that of the rest of the ball was barely 600° C. From various considerations he concludes that a uniformly heated, nearly transparent sphere should appear more luminous towards the limb. This has been verified by Wood, using a hollow glass bulb filled with a very dilute solution of rhodamine, illuminated by the mercury arc and viewed through red glass. If a spot on the surface of the bulb is finely ground with flour emery, this spot appears extremely luminous when near the limb, as a result of the liberation of the fluorescent rays which are undergoing total internal reflection.

A. W.

1128. *Fluor-crown Glass.* E. Zschimmer. (Zeitschr. Instrumentenk. 38. pp. 145-148, May, 1918. Communication from the Optical Works of Messrs. Schott, Jena.)—Describes a new kind of glass for optical purposes, the index of refraction being very low. Three types are made, the optical properties of which are shown in the following table:—

Type.	Refractive Index n_D .	Mean Dispersion ($n_F - n_C$).	$\nu = \frac{n_D - 1}{n_F - n_C}$	Specific Gravity.
O 6781	1.4988	0.00706	69.9	2.48
O 6500	1.4710	0.00701	67.2	2.81
O 7186	1.4687	0.00707	65.6	2.27

A. W.

1129. *Some Transformations in Formulæ for Refraction and Polarisation, and determination of the Pressure of Light.* A. G. Rossi. (Accad. Sci. vol. XVI.—A.—1918.

Torino, Atti, 48. 4. and 5. pp. 209-255, 1912-1918.)—It is shown how by considering the ratio of the tangents, rather than of the sines, of the angles of incidence and refraction, a magnitude is obtained which has notable physical significance, being equal to n^2 for the Brewsterian incidence, and being also the factor by which it is necessary to multiply the square of the refracted amplitude in order to obtain the intensity. Denoting the ratio of the tangents by X , the author deduces many new relations by substituting it in various well-established formulæ. Experiments are also described on the measurement of the pressure of light, employing a slight modification of the apparatus devised by Amerio [Abstract No. 588 (1910)]. W. H. Si.

1130. *Refraction and Dispersion of Gaseous Compounds.* C. Cuthbertson. (Phil. Mag. 25. pp. 592-604, April, 1918.)—The experimental results are shown in a table in the original, and the concurrent changes in absorption, so far as they are known, may be summarised as follows:—A. (1) In hydrochloric, hydrobromic, hydriodic acids, hydrogen disulphide, and sulphur dioxide, the refractivity of the compound is less than the sum of the refractivities of its constituents, and the dispersive power of the compound lies between those of its constituents. (2) In the spectra of chlorine, bromine, iodine, and sulphur, strong absorption bands occur in the violet and near ultra-violet, which disappear in the compound. B. (1) In nitrous oxide, nitric oxide, ammonia, and ozone, the refractivity of the compound is greater than the sum of the refractivities of the constituents, and the dispersive power is greater than that of either constituent. (2) In the spectra of nitrous oxide, nitric oxide, and ozone, absorption bands appear in the ultra-violet which are not present in the spectra of the elements. To explain these results the author puts forward an hypothesis which is then discussed. L. H. W.

1131. *Electric Double Refraction.* C. Gutton. (Comptes Rendus, 156. pp. 887-889, Feb. 8, 1918. Journ. de Physique, 8. Ser. 5. pp. 206-217, March, 1918.)—The experiments of Blondlot, Abraham and Lemoine, James [Abstract No. 797 (1905)] and the author, have shown that the electric double refraction of CS_2 has completely disappeared a very short time after the suppression of the electric field. The lag, if it exists, does not exceed the time during which light travels 0.5 m.; and nothing else tends to establish the existence of a lag. The experiments described in the present paper lead to the conclusion that, in a field of variable intensity, the variations of the electric double refraction do not follow exactly the variations of the field. Between a polariser and analyser at extinction, with polarisation planes at 45° to the horizontal, are placed, one behind the other, two condensers; they are immersed in different liquids whose electric double refractions have the same sign. The plates are connected two by two to the terminals of a Holtz machine, so that the two condensers are always charged to the same p.d. The lines of force are horizontal between the plates of the first condenser and vertical between those of the second; and so the condensers produce, between the two components of the light polarised vertically and horizontally, path-differences of opposite signs. The two effects can be made exactly to compensate each other by altering the distance between the plates of one of the condensers. After this compensation has been effected the condensers are connected to an oscillator giving intense Hertzian waves of half wavelength 2.2 m. If the double refraction followed instantaneously the variations of the field the compensation made for static charges would still hold, but it is found necessary to reduce the distance apart of the plates of one condenser

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by $1/26$ of the total distance (2.1 mm.) in order to secure extinction again. Hence it is concluded that the electric double refraction does not follow instantaneously the variations of the electric field. The liquids used were naphthaline bromide, and, in the variable condenser, carbon disulphide. Other liquids used were benzene, toluene, chloroform, and nitrobenzene. Chloroform has, according to Schmidt, a Kerr constant equal to that of carbon disulphide but of opposite sign. It was found possible to obtain compensation with these liquids, using two condensers with parallel plates. Passing from static to oscillatory charges, extinction was obtained again by increasing slightly (about $1/200$) the thickness of the carbon disulphide condenser. The results of these experiments can be explained by the theory of molecular orientation developed by Langevin. The magnitude of the Kerr constant seems to play the greater part in determining the duration of the establishment of electric double refraction; viscosity does not appear to be important. [See also Abstracts Nos. 880, 1020 (1912.)] A. W.

1132. *Deviations produced by Prisms.* H. S. Uhler. (Amer. Journ. Sci. 85. pp. 889-428, April, 1918.)—The problem of prismatic deviation is treated mathematically in this paper in a complete and thorough manner. The discussion has reference to the case of a single prism with unlimited plane faces, and surrounded by one medium whose absolute index of refraction is less than the absolute index of the material of the prism. A. W.

1133. *Scattering and Absorption of Light in Gaseous Media, with applications to the Intensity of Sky Radiation.* L. V. King. (Roy. Soc., Phil. Trans. 212. pp. 875-488, Feb. 8, 1918. Roy. Soc., Proc. Ser. A. 88. pp. 88-89, Feb. 24, 1918. Abstract.)—The author divides his paper into three sections: Part I. containing a general theoretical discussion, Part II. applications to the earth's atmosphere, and Part III. analysis of observations on absorption and scattering, with numerical tables and diagrams illustrating attenuation of sunlight and intensities of sky radiation. In Part I. the scattering of parallel radiation by molecules and small particles is first dealt with. Rayleigh first worked out the effect of small particles in scattering incident radiation, finding that when a stream of parallel radiation falls on a particle whose dimensions are small compared with the wave-length, the resulting secondary disturbance travels in all directions at the expense of the intensity in the original direction. Later Rayleigh gave reasons for believing that the molecules of a gas are themselves able to scatter radiation in this way. In a gaseous medium it is legitimate to sum up the intensities of the scattered radiation due to each molecule in an element of volume, without a consideration of phase-difference in consequence of the continuous change in the relative positions of a molecule in a gas. The same applies to the case where the scattering is due to small particles of dust, since these partake, to some extent, of the molecular agitation of the gas in which they are held in suspension. If E be the intensity of unpolarised radiation falling on a gas of density ρ and containing N molecules per unit volume, then the results of Kelvin and Rayleigh worked out on various hypotheses of the molecule and of the æther agree in giving rise to the expression, $\mu(\theta) = \frac{1}{2}\pi^2(n^2 - 1)^2\lambda^{-4}(1 + \cos^2\theta)E/N$, where n is the refractive index, λ the wave-length of the incident radiation, and θ the angle which the scattered radiation makes with the incident. This result has been obtained by Schuster from general considerations independent of any particular theory. The intensity of the scattered radiation is therefore twice as great in the direction of the incident radiation as it is in a direction at right angles. The effect of scattering is then shown to diminish the

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intensity of the incident radiation, giving rise to the phenomenon of attenuation especially noticeable in the diminution of intensity of solar radiation in its passage through the earth's atmosphere. A term is then introduced expressing the fact that the temperature at any point is increasing, in order to give greater generality to the analysis. The general integral equation for the scattered radiation is next deduced, and the analogy to the ordinary procedure of potential theory noted. For solving the general equation a number of simplifying assumptions are necessary, and these are considered in Part II., where the particular problem of the earth's atmosphere is taken up. The assumption is made that the earth's surface is a plane, and that the density is a function of the height above the earth's surface only, effects due to reflection from the earth's surface and refraction by the earth's atmosphere being also neglected. Expressions are then obtained, and, by a series of further assumptions, it is shown that the problem of scattered radiation in the earth's atmosphere reduces to the case of an atmosphere of uniform density contained between two parallel planes, the transformation employed being independent of any law of density with height, provided the planes of equal density are parallel to the earth's surface. Approximate solutions of integral equations are then discussed, and the solution for sky radiation given. The question of the polarisation of sky radiation is next considered. It is well known that the latter is partly polarised in a vertical plane passing through the position of the sun, and so far as the radiation to be scattered is direct solar radiation the polarisation ought to be complete. That portion of the sky radiation due to self-illumination is largely unpolarised, and may to a large extent account for this deficiency from complete polarisation. The analysis of the present paper enables the magnitude of this factor to be roughly estimated, where in default of a rigorous solution the reasonable supposition is made that the portion of the scattered radiation due to self-illumination is independent of the polarisation angle of the incident radiation.

Part III. contains the analysis of observations made on the attenuation of solar radiation by the earth's atmosphere. The cases of long- and short-wave radiation are separately dealt with, and the fact pointed out that the analytical method employed offers a convenient way of studying variations in the distribution of atmospheric dust and their connection with other meteorological phenomena. The intensity of sky radiation as calculated from the mean coefficients of attenuation at Mount Wilson and Washington is then examined. The present paper appears to support the view that at levels above Mount Wilson molecular scattering is sufficient to account completely both for attenuation of solar radiation and for the intensity and quality of sky radiation. Even at sea-level, the effect of atmospheric dust can be taken into account in a simple manner in the formulæ for absorption and scattering. The hope is expressed that should future observations support the validity of the simple formula connecting the coefficient of attenuation with the wave-length, then the coefficients for very short or very long wave-lengths may be obtained when the direct method of calculation from high and low sun observations leaves room for considerable uncertainty, owing to the small intensities in the solar spectrum at these wave-lengths and to other experimental difficulties. Thirteen exhaustive numerical tables are appended, giving comparisons of theory with observation, accompanied by explanatory diagrams.

H. H. Ho.

1134. *Propagation of Light in Non-homogeneous Media.* K. Försterling. (Phys. Zeitschr. 14. pp. 265-270, April 1, 1913.)—Adapts the electromagnetic VOL. XVI.—A.—1918.

equations to the case of a variable dielectric constant. Assuming that the variation is small and confined to one axis, the author works out a theory of the propagation of light, and shows that it covers the bulk of the phenomena observed in Lippmann's colour photography. E. E. F.

1135. *Separation of Luminous and Heating effects of a Source of Light.* Dussaud. (Comptes Rendus, 156. p. 948, March 25, 1918.)—For concentrating the light of a given source a group of optic systems is used, one succeeding the other automatically and each system taking a definite position for a certain interval of time. The heat absorbed by the system while the light is passing through it is lost by radiation, etc., while the system is out of action. This arrangement permits the source to be placed much nearer the condensing system than ordinarily is the case, and so the focal length of the system may be made half that which would be required for the same system if fixed. The light issuing from the condensing system is found to have little heating power. [See also Abstract No. 804B (1912).] A. W.

1136. *Power of "Solution" of Photographic Plates.* E. G. Goldberg. (Zeitschr. wiss. Phot. 12. pp. 77-92, April, 1918.)—The ability of photographic plates to define objects, such as lines when separated by minute distances, has been the subject of various researches, among the more recent being those of Mees and Scheffer. The method adopted to test the degree of definition by means of circular apertures is fully described in the present paper. Photographic illustrations of the results obtained, and also curves showing the connections between the various factors involved, are given. The practical outcome is considered at some length. The general results are as follows:—It is not possible to determine the ability of a plate to reproduce finer details by taking account of the so-called "Power of Solution" only. Two properties quite independent of each other must be separately considered: the relation between the increase in width of the image of a copied disc and the lighting (Trübungsfaktor), and the limit of "solution"; the latter probably depends on the degree of difference in light sensitivity of the single grains of the emulsion. Methods of determining these factors are elaborated. A. E. G.

1137. *Measurement by Means of Registering Microphotometers of the Blackening Distribution in Wedge Slit Photographs obtained with Röntgen Rays.* P. P. Koch. (Ann. d. Physik, 40. 4. pp. 797-811, April 15, 1918.)—A modified form of Hartmann's microphotometer has been previously described [Abstract No. 1522 (1912)]; the instrument has also been used for taking measurements of slit photographs obtained by Walter and Pohl [Abstract No. 1224 (1909)]. It is important that the results obtained by this means should be verified by another method, on account of the light they throw upon the nature of Röntgen rays and the determination of their wavelength. It is now shown that an independent method giving results in good agreement can be applied, but it is suggested that the suitability of the photographic plates for such measurement should be made the subject of research. A. E. G.

1138. *Flare-spots in Photography.* G. F. C. Searle. (Cambridge Phil. Soc., Proc. 17. pp. 205-219, April, 1918.)—Rays of light that have been twice reflected within a lens system (such as a photographic lens) may give rise to *ghosts* and *flare-spots*. Experiments are described with spectacle lenses illustrating these phenomena. Theory is given. A. W.

1139. *Photometry of Photographic Negatives.* G. Neumann. (Phys. Zeitschr. 14. pp. 241-245, March 15, 1918.)—Describes a simple arrangement adapted to any optical bench. Uses a Lummer-Brodhun cube, and plaster plates illuminated by two slits closed by ground-glass plates. The illumination is by a Nernst lamp, as the light is somewhat feeble. Observation is made through a telescope magnifying three times. E. E. F.

1140. *Rainbows.* W. Möbius. (Ann. d. Physik, 40. 4. pp. 786-747, April 15, 1918. Extract from Preisschrift. d. Fürstlich Jablonowsk. Gesell., Leipzig, No. 42. pp. 1-81, 1912.)—A mathematical treatment of the theory of rainbows formed at spheres of diams. from one to ten wave-lengths of the light. The paper is illustrated by a number of graphs showing the fluctuations of the functions concerned. [See Abstracts Nos. 258 (1909) and 1728 (1910).] E. H. B.

1141. *New Mirror Stereoscope.* C. Pulfrich. (Zeitschr. Instrumentenk. 82. pp. 887-847, Nov., and pp. 865-871, Dec., 1912. Communication from the Optical Works of C. Zeiss, Jena.)—Deals at length with the special form of prism required, having the largest possible picture angle. L. H. W.

1142. *New Spectrophotometer with Savart's Polariscopes.* M. Wagner. (Zeitschr. Instrumentenk. 88. pp. 149-152, May, 1918.)—Describes, with diagram, the construction of a spectrophotometer similar in principle to the apparatus used by Umow. [Abstracts Nos. 2048 (1909) and 169 (1918).] A. W.

1143. *A Graphic Method of Optical Imagery.* W. R. Bower. (Phys. Soc., Proc. 25. pp. 160-177, April, 1918.)—A development of optical imagery based on elementary geometry, including limiting positions, but excluding cross-ratios, centres of perspective, etc. L. H. W.

1144. *Illumination and Eyestrain.* E. M. Alger. (Amer. Illum. Engin. Soc., Trans. 8. pp. 180-187; Discussion, pp. 188-148, March, 1918.)

1145. *Corrections in a Newton's-rings System.* A. Ferguson. (Phil. Mag. 25. pp. 501-506, April, 1918.)

1146. *Fringes of Crystalline Plates with Parallel Faces.* C. Raveau. (Comptes Rendus, 155. pp. 965-968, Nov. 11, 1912.)

1147. *Absorption of Ultra-violet Light by Acetylene.* V. Henri and M. Landau. (Comptes Rendus, 156. pp. 697-699, March 8, 1918.)—A study was made of the absorption by the gases CH_4 , C_2H_2 , C_2H_4 , C_2H_6 , CO , and CO_2 . Instead of using as the source of light a condensed spark between Al electrodes in water, which necessitates long exposures on account of the feeble luminosity of the spark, the authors employed a high-frequency spark between Al electrodes in water, thereby obtaining a very luminous continuous spectrum in the whole ultra-violet region as far as $\lambda 2150$, the exposures necessary being only from 80 secs. to 8 mins. The results given are only for pure acetylene (i) gaseous at ordinary temperature and pressures from 1 to 0.1 atmo., (ii) in alcoholic solution. The ultra-violet absorption spectrum of gaseous acetylene is fluted and possesses a great number of bands, from $\lambda 8157$ to $\lambda 9286.4$. These bands are more or less sharp according to position. Many of them examined at high magnification are resolved into series of very
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fine bands, less than 1 Å. apart. Three groups of bands are distinguished. The first, and sharpest group, extends from $\lambda 8157$ to $\lambda 2880$; they have sharp edges on the ultra-violet side and are shaded off towards the red. The frequency-difference Δn of the heads of the bands is constant, the mean value of Δn being 28. Towards $\lambda 2960$ a second set of bands begins to appear between the bands of the first group, and between $\lambda 2800$ and $\lambda 2500$ there are a great number of bands, some with sharp edges on the ultra-violet side, others with diffuse edges. They have not been classified. Between $\lambda 2500$ and $\lambda 2827.5$ gaseous acetylene at a thickness of 40 cm. shows no appreciable absorption. A third group begins about $\lambda 2827.5$ and extends to $\lambda 2286.4$; they have sharp edges on the ultra-violet side, are resolvable into series of extremely fine bands, and the frequency-differences of the heads of the bands increase in a regular manner. Alcoholic solutions of acetylene show a single very large absorption band commencing about $\lambda 2860$ and having a maximum about $\lambda 2681$. It is interesting to note that the absorption of ultra-violet light by acetylene and, as will be shown later, by the other carbides of hydrogen, commences about the region where the ultra-violet solar spectrum terminates. This fact could serve as the basis of a supposition of the presence of carbides of hydrogen in the solar atmosphere. [See also Abstract No. 980 (1918).] A. W.

1148. *Satellites of the Mercury Lines.* R. W. Wood. (Phil. Mag. 25. pp. 443-449, April, 1918. Phys. Zeitschr. 14. pp. 278-275, April 1, 1918.)—A plane grating arrangement of 42 ft. focal length was used to study the structure of the mercury lines 5769, 5790, 5461, and 4859. The grating had high resolving power, about that of a large echelon. Photographs are reproduced of the lines with their satellites, and the results are discussed with reference to those previously obtained by other investigators. A. W.

1149. *Distribution of Emission in the Arc between Metal Rods.* H. KÖNEMANN. (Zeitschr. wiss. Phot. 12. pp. 65-76, April, and pp. 128-142, May, 1918.)—The arc spectra of a series of metals—Sn, Zn, Pb, Ca, Ti, Cd, Mg, Al, Cu, Ag—were obtained with a quartz spectrograph, and the distribution of the emission was investigated in the region from $\lambda 4000$ to $\lambda 2000$. The appearance of spark lines in the arc, up to the present known only in certain cases, is shown to be a general property of the arc spectrum. Between the two poles of the arc a number of lines are shown to have uniform intensity; other lines are stronger at both poles, while others again are found only at the negative pole or at the positive pole, or at both. Also in the same spectrum sometimes one, sometimes the other pole shows increased intensity. Among the lines which show no increased intensity at the poles are many arc lines. Lines which show the greatest difference, or appear only at the poles, are the spark lines known as enhanced lines. The author's results are in agreement with those of other workers as regards a large number of the "pole" lines, but not for all lines showing increased intensity. The majority of the lines strengthened at the poles are found in the extreme ultra-violet. The intensity ratio of the spark lines in the arc is different from that of the enhanced lines in the spark. Different groups of enhanced lines were investigated. The appearance of the spark lines in the neighbourhood of the pole explains the difference of the ultra-violet spectra with long and short arcs, observed by many investigators. The spectral behaviour is compared with the thermal, chemical, and electrical properties of the corresponding element: a definite relation could not be established. A discussion of the causes giving rise to

differences of spectra leads to the conclusion that neither temperature distribution alone, nor distribution of potential gradient alone, nor other conditions alone can explain the appearance of the spark lines. A. W.

1150. *Remarks on Vegard's Researches.* J. Stark. (Ann. d. Physik, 40. 4. p. 785, April 15, 1918.)—Stark adheres to the explanation previously given by him [see Abstract No. 601 (1918)] rather than to that put forward by Vegard. The complicated nature of the methods employed renders it practically impossible to decide between the two hypotheses, and, further, the dispersion obtained with the spectrographs used was insufficient. On this account further observations with instruments of greater dispersion are being carried out on the intensity distribution in the canal-ray spectrum. A. E. G.

1151. *Zeeman-effect.* A. Sommerfeld. (Ann. d. Physik, 40. 4. pp. 748–774, April 15, 1918.)—The author explains the recent results of Paschen and Back [see Abstract No. 419 (1918)] by a modification of the elementary Lorentz theory: instead of the field of quasi-elastic force which binds the electron to its equilibrium position being isotropic, it is assumed to be æolotropic. If the three resulting frequencies are nearly equal, we have a close triplet-doublet, special of two equal frequencies. For small fields, i.e. $(e/m) H < \Delta n$ (Δn greatest of the three frequency-differences $n_1 - n_2, n_2 - n_3, n_3 - n_1$), the triplet expands proportionally into H^2 . For large fields, i.e. $(e/m) H > \Delta n$, the electron behaves asymptotically as an isotropic electron, that is, it gives normal triplet and separation proportional to H . J. M.

1152. *Photoelectric Investigation of Fluorescent Substances.* W. E. Pauli. (Ann. d. Physik, 40. 4. pp. 677–700, April 15, 1918.)—A series of fluorescent substances was investigated with regard to their photo-electric behaviour when illuminated with ultra-violet light. A set of suitable substances was also dealt with, using light from the visible spectrum. A photo-electric effect was found with all such substances first with an illumination whose max. wave-length was $420 \mu\mu$. The effect found when using ultra-violet light for illumination was on the average very small, being from 1/100 to 1/500 of the effect obtained with zinc. With the substances for which light in the visible spectrum was used the susceptibility-distribution of the fluorescence was investigated by a new method. No connection was found between the photo-electric effect and the susceptibility-distribution. The results are utilised as basis for theory. It appears probable that there is a difference of structure between molecules possessing fluorescent and those possessing phosphorescent properties. A. W.

1153. *Interference Phenomena with Röntgen Rays.* W. Friedrich, P. Knipping, and M. Laue. (K. Bayer. Akad. München, Ber. pp. 808–822, 1912. Le Radium, 10. pp. 47–57, Feb., 1918.)—According to generally accepted theory, the atoms in crystals are arranged in a regular manner as regards spacing throughout the whole of the crystal. Therefore if X-rays fall on a crystal, interference effects ought to be observed if the X-rays are similar to light-waves of very short wave-length. In the experiments described a narrow pencil of X-rays fell on a crystal having a photographic plate placed behind it and normal to the beam. Exposures of many hours were made, and on development it was found that, in addition to the central image caused by the main beam, regularly arranged spots were present on the plate. With powdered CuSO_4 , for example, no such effects were observed. VOL. XVI.—A.—1918.

The effects were found with crystals of CuSO_4 , rock-salt, diamond, and zinc blende. With the plate of the latter (a cubic crystal) $1.0 \times 1.0 \times 0.05$ cm., cut parallel to one of its principal axes, an extended series of photographs were made with the crystal orientated at different angles. A theoretical examination of the position of the spots in the various photographs is given by the last-named author, the crystal being treated as a three-dimensional diffraction grating and the spots as due to the reinforcement of the waves in different directions. The calculated positions of the spots are in good agreement with theory, it being also assumed that definite wave-lengths are present, presumably corresponding to the characteristic X-radiations from the zinc and the sulphur. Five definite wave-lengths are given, varying between 1.27 and 4.83×10^{-9} cm.

E. M.

1154. Multiple Images by Röntgen Rays after Traversing a Crystal. M. de Broglie. (Comptes Rendus, 156. pp. 1011–1013, March 31, 1918.)—Using practically the same arrangement as Friedrich, Knipping, and Laue [see preceding Abstract], the present author has tried rock-salt immersed in liquid nitrogen, rock-salt in a transverse magnetic field of 10,000 units; he has also examined blende, fluorine, and magnetite without discovering any marked departures from the original phenomena.

E. H. B.

1155. Reflection of Röntgen Rays. M. de Broglie. (Comptes Rendus, 156. pp. 1153–1155, April 14, 1918.)—An experimental study of the reflection of X-rays from rock-salt and magnetite, with six photographic reproductions of the results obtained. The various reflected images occur in a ring form. It is asserted that bands were obtained in some of them. The reflection was obtained from bismuth also, but not from flint-glass. [See preceding Abstract.]

E. H. B.

1156. Reflection of X-Rays. M. de Broglie. (Nature, 91. pp. 161–162, April 17, 1918.)—The paper contains interesting diagrams of the distribution of the pencils of X-rays due to the scattering of a very narrow beam by various crystals. The author considers that the transmitted “spots” of Friedrich, Knipping, and Laue are due to the same cause as the reflected spots obtained by allowing a beam of X-rays to fall on a face of a crystal at almost grazing incidence. The results show that the spots produced on a photographic plate by the pencils scattered from the crystal are generally striated by parallel fringes both in the case of reflected spots and transmitted spots. Similar phenomena are obtained with ordinary light and two ordinary (200 lines to the mm.) gratings when the incident beam forms similar angles of incidence with the plane of the gratings.

E. M.

1157. Interference of Röntgen Rays. G. Wulff. (Phys. Zeitschr. 14. pp. 217–220, March 15, 1918.)—Develops Laue's theory of the diffraction patterns obtained on transmitting X-rays through a crystal [Abstract No. 1156 (1918)], in which the crystal is regarded as a three-dimensional grating. Every position of the crystal produces a distinct interference pattern, and a displacement of a very few degrees may alter the type of pattern entirely. It may always, however, be brought into relation with the crystalline structure.

E. E. F.

1158. Reflection of Röntgen Rays. L. Mandelstam and H. Rohmann. (Phys. Zeitschr. 14. pp. 220–222, March 15, 1918.)—The “reflection” of

X-rays by mica is intensified by a cleavage of the crystal. Reflection is strongest where the cleavage is apparent, but it is also strengthened for some distance round the cleavage patch. The authors believe that the "interference" patterns found are largely due to reflection from cleavage planes within the crystal, whether the cleavage is apparent or not. E. E. F.

1159. *X-Ray Spectra.* E. A. Owen and G. G. Blake. (Nature, 91. p. 185, April 10, 1918.)—A beam of rays from a Röntgen bulb was directed through a slit on to the cleavage surface of a crystal of selenite at almost grazing incidence, the beam being made practically parallel by means of suitable lead stops. The photographs taken of the reflected beam all show exceedingly well-defined lines, which are not equally spaced, their number and distances apart varying according to the particular bulb used. These lines are parallel to each other and to the slit. The hardness of the bulb affects the relative intensity of the lines, but apparently makes no difference to their relative positions, the results suggesting that the rays of longer wave-length are less deviated than those of shorter wave-length. The results further suggest that the lines obtained may be spectral lines in the spectra of the beams emitted from the respective bulbs. E. M.

1160. *X-Rays and Crystals.* T. Terada. (Nature, 91. pp. 185-186, April 10, and p. 218, May 1, 1918.)—Repeating the experiments of Friedrich, Knipping, and Laue [Abstract No. 1158 (1918)] on the transmission of X-rays through crystals, the author finds that the transmitted rays may easily be made visible on an ordinary fluorescent screen when a sufficiently large and intense pencil is used. The X-ray tube used was a Müller-tube of 20 cm. diam. with water-cooling, the current being supplied by a Toepler influence machine. The diam. of the pencil of rays was 0.5 to 1.0 cm. The crystals examined were borax, alum, mica, fluor spar, rock-salt, rock-crystal, cane-sugar, etc. The transmitted rays showed numerous detached fluorescent spots of elongated shape. If the crystal is rotated about an axis perpendicular to the incident ray, the spots move generally across the central spot caused by the main beam, but the axis of rotation may be chosen so that some of the spots remain stationary while the crystal is rotated. Groups of detached pencils appeared to be arranged on circular cones touching the incident pencil, the aperture of the cones varying continuously with the inclination of the crystal. The results of the observations are favourable to the explanation suggested by W. L. Bragg, that planes in the crystals rich in molecules or atoms behave as reflecting planes for rays at grazing incidence [see Abstract No. 604 (1918)]. E. M.

1161. *Diffraction Patterns from Crystals.* H. S. Allen. (Nature, 91. p. 268, May 15, 1918.)—A cylindrical pencil of light of very small cross-section was allowed to fall upon a crystal of selenite or phlogopite with a photographic plate placed about 20 cm. behind the crystal. The resultant image often showed lines or streaks radiating from the centre at angles depending on the crystal and its orientation. Tutton (Ibid.) considers the streaks in the photographs as due to "asterism" caused by fine enclosures arranged along the glide planes, and parallel to the cleavage plane. E. M.

1162. *Reflected X-Rays.* E. Hupka. (Nature, 91. p. 267, May 15, 1918.)—Diagrams are given representing the photographs obtained when X-rays are reflected on rock-salt and quartz. In the case of the latter there are five spots
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due to the impact of the reflected rays, the central spot and the two outside ones being the more intense. An explanation is given by considering the positions of the molecules, in the quartz, at the corners of hexagons in planes at right angles to the optic axis. The more intense spots are due to reflection by layers of molecules parallel to the three principal directions. The two weaker spots are due to reflection by layers of molecules not so close together as in the former case. In addition to the spots there are, with both rock-salt and quartz, a series of lines which seem to converge towards the points of impact of the reflected rays and are distributed in a way which is very similar to the spectrum obtained with visible light by means of two crossed gratings. This seems to suggest that the directly reflected rays must be regarded as spectra of the order zero. On account of the diffusion of the lines, however, it is not possible at present to deduce from this the wave-length of the X-rays. E. M.

1163. *Pulse Theory of X-Rays, γ -Rays, and Photo-electric Rays.* W. F. G. Swann. (Phil. Mag. 25. pp. 584-557, April, 1918.)—It is well known that when a beam of X-rays or ultra-violet rays falls upon a thin sheet of metal, the values for the number and velocity of the β -rays produced are greater for the emergence β -rays than for the incidence ones. In the present paper the author examines the question as to what extent the want of symmetry in the expulsion of these β -rays may be reconciled with the pulse theory. When a beam of electromagnetic rays encounters a free electron the motion which the train produces is generally treated as being wholly transverse to the direction of the beam. The magnetic field of the electromagnetic train acts on the moving electron, however, with a force parallel to the line of motion of the beam, and, in the case of a free electron, this force is such that the total velocity which it has produced since it started to act is always in the direction of the advancing wave, so that the electron will move in the direction of the wave as well as in the transverse direction. Proceeding on this basis, the author calculates the magnitude of the want of symmetry in the expulsion of β -rays. A more powerful theory is, however, deduced by considering the β -rays to arise not from free electrons, but from electrons inside the atoms. A formula is deduced on this basis which corresponds to a case where the electrons are ejected from the atom entirely in the direction in which the waves are travelling. This formula agrees with observations for X-rays, the fact that some β -rays come out against the wave-train being explained as due to scattering. A modified form of this theory is discussed, applicable to photo-electric effects and becoming identical with the theory for X-rays. The paper concludes with some remarks on filamentary pulses and a calculation of a possible relation between the widths of the pulses and the wave-lengths. For the various details, chiefly mathematical, the original paper must be consulted. E. M.

1164. *Production of Fluorescent Röntgen Radiation.* W. H. Bragg. (Phil. Mag. 25. pp. 657-659, April, 1918.)—A reply to J. C. Chapman [Abstract No. 997 (1918)], who attacked an hypothesis of the author's [Abstract No. 1496 (1911)], according to which an intermediate kathode ray conveys the energy from the primary X-ray to the homogeneous secondary ray. Chapman's objection is based on an experiment showing that the homogeneous characteristic X-radiation excited in a compound radiator of sheets of gold and paper is independent of the arrangement of the sheets, i.e. presumably independent of whether the corpuscles ejected from the gold

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sheets are absorbed in paper or in other gold sheets. The author objects to Chapman's calculation of the amount of energy of corpuscular radiation which emerges from the gold sheets, as this calculation is based on the absorption of the ejected corpuscles by other gold sheets. It is possible that the excited cathode rays which have special power of exciting homogeneous X-rays in gold are abnormally absorbed, and that very few of them emerge from the foil. The author gives preliminary results of new experiments which are in agreement with his theory. The cathode rays produced by Mo X-rays are shown to be deficient in both penetration and ionising power in ethyl bromide. This would follow from the theory, since Mo is of slightly higher atomic weight than Br, and Mo-rays can therefore excite the characteristic homogeneous X-rays in Br and thus lose energy in this special way.

E. M.

1165. *Excitation of γ -Rays by the α -Rays of Ionium and Radio-thorium.* J. Chadwick and A. S. Russell. (Roy. Soc., Proc. Ser. A. 88. pp. 217-229, March 81, 1918.)—It has been shown by Chadwick [Abstract No. 481 (1918)] that when the α -particles of RaC impinge on matter, a small amount of γ -radiation is excited. In the present experiments this result has been extended to the α -rays of ionium, and owing to the absence of primary β - or γ -radiation, it has been possible to study the excited γ -rays in much more detail. The preparation of ionium used consisted of 1.2 gm. of a mixture of the oxides of ionium and thorium emitting about 10^8 α -particles per sec., *i.e.* the mixture contained a quantity of ionium equivalent to the amount of radio-active equilibrium with 8 mgm. of Ra. All radio-active impurities emitting considerable amounts of β - or γ -rays were first separated by chemical means. The resulting substance had a β and γ activity of 18.8 divs./min. under the experimental conditions, of which 12.0 divs./min. was due to γ -rays. Observations were made of the absorption of the γ -rays by Al, the small amount of β -rays being prevented from entering the electroscope by means of a strong magnetic field. The radiation was found to consist of three distinct types whose values of μ/D were I. 400; II. 8.85; III. 0.15; μ being the absorption coefficient in Al of density D. It is shown that most of the energy of the whole radiation is confined to the softest type, *i.e.* Type II. appears to have the penetrating power corresponding to Barkla's characteristic excited X-radiation of series L in either ionium or thorium, and presumably I. and III. are types of characteristic radiation corresponding to other series not yet fully known. The results are thus in agreement with Rutherford's idea [Abstract No. 488 (1918)] that the γ -rays of radio-active bodies are the characteristic X-radiations of these bodies. Further experiments with Radio-Th showed that this product also emits a small quantity of soft γ -radiation.

E. M.

HEAT.

1166. Measurement of Specific Heats of Metals at High Temperatures. **O. M. Corbino.** (Accad. Lincei, Atti, 22. pp. 480-487, April 6, 1918.)—For the determination of the specific heats at high temperatures, of Pt and other metals, the author has slightly modified the method previously described [Abstract No. 1068 (1912)]. The metal filament, which still forms one of the arms of a Wheatstone bridge, is suspended in a vessel capable of being evacuated by means of a Gaede pump to 0.0001 mm. By suddenly reducing the resistance in the principal circuit the current in the filament, and consequently its temperature, is increased, and from this the ratio c/a is deduced.
W. H. St.

1167. Adiabatic Expansion in Liquids. **L. Gay.** (Comptes Rendus, 156. pp. 1070-1072, April 7, 1918.)—The author has devised an apparatus for measuring the dilatation produced in liquids by adiabatic expansion from a pressure of 2 atmos. to 1 atmo. From the results obtained with mercury, water, and benzene, the values of the coefficient of isothermal compressibility, β , are calculated from the expression $\beta = \gamma + T\alpha^2/41.8cD$, where γ is the coefficient of adiabatic compressibility (which is obtained experimentally), α the coefficient of thermal expansion, c the specific heat at constant pressure, and D the density. The values obtained correspond moderately well with those found by Amagat [see Abstract No. 1258 (1909)].
T. H. P.

1168. Experiments on Heat Insulation. **F. A. J. FitzGerald.** (Amer. Electrochem. Soc., Trans. 21. pp. 535-541; Discussion, pp. 541-544, 1912.)—Some experiments with furnaces built up of various kinds of fire-bricks enclosing a cylindrical resistor of alundum wound with nichrome wire. The discussion by **M. M. Kohn** and **L. H. Duschak** concerned chiefly the influence of cellular spacing.
H. B.

1169. Hydrogen- and Resistance-thermometer between 0° and -198° C. **F. Henning.** (Ann. d. Physik, 40. 4. pp. 665-667, April 15, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—Platinum and lead thermometers are compared with the hydrogen thermometer between 0° and -198° C. The accuracy of the gas thermometer at constant volume is discussed and a simple formula deduced for the calculation of the gas thermometer temperature. The measurements were made in liquid air, liquid oxygen, and, beyond -150°, in a specially constructed thermostat, whose temperature could be kept constant to within 0.02 to 0.08°. The Callendar formula for the Pt-thermometer holds till -40°. At -198° the difference is over 2°. Elaborate tables are given with the constants relating to the gas- and Pt-thermometers.
J. J. S.

1170. On the Rectilinear Diameter for Argon. **E. Mathias, H. Kamerlingh Onnes, and C. A. Crommelin.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 667-673, Nov. 28, 1912, and pp. 960-965, April 24, 1913. Communication No. 181a from the Phys. Lab., Leiden. Comptes Rendus, 156. pp. 129-132, Jan. 18, 1918.)—The authors have determined
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mined the following values for the densities of liquid and vaporous argon, and the ordinates of the diameter :—

Bath.	$t_K = T - T_0^{\circ}\text{C.}$ Kelvin degrees.	$\rho_{\text{liq. r.}}$	$\rho_{\text{vap. r.}}$	$D_{pr}(\text{Obs.})$	$D_{pr}(\text{Calc.})$	O - C.
O ₂	- 188.15	1.37396	0.00801	0.69099	0.69006	+ 0.00093
CH ₄ ...	- 175.89	1.32482	0.01457	0.66970	0.66970	—
CH ₄ ...	- 161.23	1.22414	0.08723	0.63069	0.63255	- 0.00186
C ₂ H ₄ ...	- 150.76	1.18851	0.06785	0.60318	0.60508	- 0.00190
C ₂ H ₄ ...	- 140.20	1.08456	0.12552	0.58004	0.57738	+ 0.00266
C ₂ H ₄ ...	- 135.51	0.97385	0.15994	0.56690	0.56507	+ 0.00183
C ₂ H ₄ ...	- 131.54	0.91499	0.19432	0.55466	0.55466	—
C ₂ H ₄ ...	- 125.17	0.77289	0.29534	0.53412	0.53794	- 0.00382

The slope of the diameter is given by $b_d r = -0.0026285$, which is a larger coefficient than is found for any other substance except xenon. The deviations of the diameter from rectilinearity are sufficiently small to enable us to say that argon obeys the law of the diameter, but they are too large and too systematic to be due to experimental errors.

The authors also discuss the deviations of equations of state for different substances from one another. [See also Abstract No. 1851 (1912).] A. F.

1171. *Isotherms of Monatomic Substances and of their Binary Mixtures.* XIV. *Calculation of Thermal Quantities for Argon.* **H. Kamerlingh Onnes** and **C. A. Crommelin.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 952-960, April 24, 1918. Communication No. 188c from the Phys. Lab., Leiden.)—The empirical reduced equation of state for argon [see Abstract No. 1851 (1912)] allows of the calculation of a number of thermal quantities which are essential to a knowledge of monatomic substances in general and of argon in particular. These quantities may also be obtained graphically, but calculation by means of an equation which fits the experimental results over the whole region of observation admits of greatly increased accuracy. The present paper contains values of $(\partial p/\partial T)_v$, $(\partial^2 p/\partial T^2)_v$, $(\partial \gamma_v/\partial v) = T(\partial^2 p/\partial T^2)_v$, $(\partial u/\partial v) = T(\partial p/\partial T)_v - p$, and of Reinganum's a and $a_s = [T(\partial p/\partial T)_v - p]v^2$, calculated as functions of the temperature and of the density from the equation referred to above; the temperature is expressed in Kelvin degrees, and is calculated from 0°C. , while the pressure is expressed in international atmospheres. The importance of a knowledge of these quantities, especially as functions of the temperature, has been repeatedly emphasised [see Reinganum, Abstract No. 329 (1906)], but it may be pointed out that, according to the main van der Waals' equation with constant a_v , b_v , and R_v , $(\partial p/\partial T)_v$, the values of $(\partial u/\partial v)_T$ and a_s should be independent of the temperature, and consequently $(\partial^2 p/\partial T^2)_v$ should vanish, so that the deviations which they all show may be taken as a measure of the degree to which argon diverges from the simple assumptions regarding molecules accepted by van der Waals in developing his principal equation. At least approximate agreement with the van der Waals' equation would first be expected with monatomic substances, and comparison of the results obtained for argon with those for substances of more complex molecular structure should lead to conclusions of the greatest importance. As regards $(\partial p/\partial T)_v$, the behaviour of argon corresponds in many respects with that of isopentane. For this hydrocarbon Young (Phys. Soc., Proc. 13. p. 602, 1895) found that

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$(\partial p/\partial T)_v$ decreases as the temperature falls when v_r is less than 4.6 c.cm.; for greater volumes up to 400 c.cm. it increases as the temperature falls, while it remains practically constant at still greater volumes. In the case of argon, for which the volumes are expressed in terms of the normal volume as unit, if the law of corresponding states were accurately obeyed these volumes would correspond with $v_n = 0.00877$ and 0.328 or $\rho_n = 285$ and 8.05 . The observations made on argon lie entirely within these limits, and argon agrees with isopentane over the whole region. The value of $(\partial p/\partial T)_v$ always falls with rise of temperature, but at the lowest density the diminution becomes extremely small, pointing to constancy at still lower densities. As with isopentane, so also with argon, the value of $(\partial^2 p/\partial T^2)_v$ is less than zero when v is greater than $\pm v_k$.
T. H. P.

1172. *Propagation of Explosions in Mixed Gases, and on the Limits of Inflammability.* E. Jouguet. (Comptes Rendus, 156. pp. 872-875, March 17, and pp. 1058-1061, April 7, 1918.)—A theoretical treatment.

1173. *Present Status of the Temperature Scale.* G. K. Burgess. (Chem. News, 107. pp. 169-171, April 11, and pp. 182-184, April 18, 1918. Paper read before the Internat. Congress of Applied Chemistry, New York, 1912.)

1174. *A New Entropy Analogue.* V. Karapetoff. (Gen. Elect. Rev. 16. pp. 7-15, Jan., 1918. Eng. News, 69. pp. 406-409, Feb. 27, 1918.)

1175. *On Two Fundamental Inequalities in Thermodynamics.* P. Duhem. (Comptes Rendus, 156. pp. 421-424, Feb. 10, 1918.)

1176. *Radiation Determinations.* W. Gerlach. (Ann. d. Physik, 40. 4. pp. 701-710, April 15, 1918.)—Defends the author's position against criticisms that have been advanced. [See Abstracts Nos. 1229 (1912) and 99 (1913).]
E. H. B.

SOUND.

1177. *Pianoforte Touch.* G. H. Bryan. (Phys. Soc., Proc. 25. pp. 147-156; Discussion, pp. 156-159, April, 1918.)—The author discusses Helmholtz's and Kaufmann's theories of the vibrations of a pianoforte wire excited by impact, with special reference to the effects obtainable with the modern pneumatical piano-players and player-pianos, and the common widespread belief that these can never reproduce the touch of the human fingers. While the rendering of many commercial piano-players in the hands of an average performer bears little resemblance to the performance of a professional pianist, the author finds that there is generally believed to be a certain element missing even in music played by a skilled performer on a first-class modern piano-player, this missing element being commonly associated with what is described as "touch."

The question turns very largely on the extent, if any, to which the *quality* of individual notes can be varied by striking the notes in different ways, namely, so as to cause different time variations of pressure on the keys while they are being depressed. The author then describes a device to control the touch to some extent. In the discussion, G. H. Berry said that with regard to the question of varying the time of contact of hammer with string by variations in the touch, in his opinion it was impossible to do this. When the hammer was in contact with the string the key was entirely disconnected from it, and also the *check* was merely a repetition device, and did not come into action until the hammer had left the string. The only thing that could be varied (neglecting the loud and soft pedals) was the velocity with which the hammer struck. It seemed to him that Bryan's device gave a greater control over this velocity. T. H. Churton said an examination of the mechanism of a piano made it evident that, no matter how a key was depressed, the result depended entirely upon the velocity imparted to the hammer that struck the wire or wires, and that the only further effect of holding the key down was to hold the damper off the wires. It was therefore evident that no variety of tone could be produced in a piano that depended upon the striking of the key which could not be produced by suitable mechanical means for striking the key with the required force. But what was ordinarily conveyed by *touch* was not tone production, nor degree of force used, but the effect produced by (1) the relative loudness of the notes played whether struck simultaneously or in sequence; (2) the relative duration of the notes and rests (*staccato* or *legato*); and (3) the slight variations from the strict time of playing individual notes or groups of notes. The author quoted some experiments to show that the quality of tone was affected by the time of contact of hammer and wire.

E. H. B.

1178. *Transverse Vibrations of Strings.* G. Sizes. (Comptes Rendus, 156. pp. 1284-1286, April 21, 1918.)—Describes observations on the vibrations of a piano string (*la*₁) of 27 per sec., and showing *undertones* as well as the usual overtones. The relations of the frequencies of the tones observed are as follows:—

Undertones ...	1, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20, 80, 82, 40, 48, 60.
Prime tone ...	64 (really 27 per sec.).
Overtones ...	96, 128, 160, 192, 256, 512, 576.

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1179. *Unipolar Induction.* **E. H. Kennard.** (Phys. Zeitschr. 14. pp. 250-251, March 15, 1918.)—A further reply to S. J. Barnett [see Abstract No. 1859 (1912) and 209 (1918)]. The fact that the charge on a cylindrical condenser revolving in a magnetic field is independent of the dielectric constant may be amplified as follows :—When a rigid system consisting of conductors and an homogeneous dielectric surrounded by a conducting surface revolves about a magnetic axis of symmetry (or “is cut by moving lines of force”), any distribution of electrification which may take place is independent of the dielectric constant. E. E. F.

1180. *Electric Conduction by Free Electrons and Carriers.* **P. Lenard.** (Ann. d. Physik, 40. 8. pp. 898-487, March 20, 1918.)—The first part of a theoretical treatise in which it is endeavoured to collate and systematise existing experimental knowledge on these subjects and present an embracing theory of the phenomena. [See Abstract No. 1479 (1910).] E. H. B.

1181. *Law of Induction and Electron Theory.* **K. Pichelmayer.** (Elektrotechnik u. Maschinenbau, 81. pp. 462-466, June 1, 1918.)—A theoretical discussion of the phenomenon of current induction in the light of the electron theory. G. E. A.

1182. *On the Electrification associated with Dust-clouds.* **W. A. D. Rudge.** (Phil. Mag. 25. pp. 481-494, April, 1918.)—The paper describes some laboratory experiments made on the electrification of dust particles raised into a cloud by the passage of a current of air. It is found that the sign of the charge depends on the nature of the material of which the dust is composed ; non-metallic elements give positively-charged clouds, metallic elements negatively-charged ones. Further experiments showed that the air containing the dust-cloud was oppositely charged to the dust particles. Illustrations are given of “Lichtenberg” figures formed by allowing the charged dust particles to settle upon an ebonite plate which has been touched for an instant with the knob of a charged Leyden jar. J. S. Di.

DISCHARGE AND OSCILLATIONS.

1183. *Generation of Light by Canal Rays.* **L. Vegard.** (Ann. d. Physik, 40. 4. pp. 711-784, April 15, 1918.)—The author has previously made a number of observations and measurements with the object of ascertaining the law governing the generation of light in gases at low pressures, and especially studied the light-emission by canal rays [see Abstract No. 118 (1918)]. That research, which dealt chiefly with the emission of the hydrogen series spectrum, led to a result which stands in express contradiction to the explanation offered by Stark of the connection between light-emission and the kinetic energy of the rays. Stark has offered further explanations tending to
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make the results obtained accord with his original hypothesis [see Abstract No. 601 (1918)]. As a result of the present investigation the following are among the conclusions arrived at :—The displacement of the ratio H_α/H_β observed by Stark and Steubing is still unexplained. Only a small fraction of the effect can be explained by the effect and relationships observed by the author. The pressure effect with the intensity distribution of the series spectrum is purely a pressure effect. The moving intensity shows no established alteration of the intensity distribution with the potential. Stark's explanations are still further criticised.

A. E. G.

1184. Primary Velocity of Canal Rays under Different Conditions. K. Glimme and J. Koenigsberger. (Deutsch. Phys. Gesell., Verh. 15. 7. pp. 267–270, April 15. 1918.)—It has not yet been definitely proved whether the primary velocity of the canal rays depends solely upon the p.d. in the discharge tube. In the present experiments the max. velocity of hydrogen atoms is compared with the discharge potential of an electric machine giving about 2×10^{-4} amp. current, by means of the electrostatic deflection of the positive hydrogen canal rays in a high vacuum. It is found that the form of the discharge tube has no effect. The max. velocity of these canal rays, under the conditions investigated, is independent of the causes which determine a certain discharge potential ; it always corresponds to the latter, and stands in constant relationship to the kathode-ray velocity.

A. E. G.

1185. Various Photoelectric Phenomena of Anthracene and their Relations to Fluorescence and Formation of Dianthrane. M. Volmer. (Ann. d. Physik, 40. 4. pp. 775–796, April 15, 1918. Extract of Habilitationsschrift, Leipzig.)—Photoelectric sensitiveness of dissolved substances, which is rendered evident in increased conductivity of the solutions, may be due either to direct ionisation similar to that of a gas by ultra-violet light or to photochemical formation of a new substance which undergoes strong electrolytic dissociation. The first of these effects has not yet been observed. According to Byk and Borck [see Abstract No. 1478 (1910)], the increase produced in the conductivity of anthracene solutions under the influence of light is due to the formation on the electrodes of a solid layer, which exhibits the Hallwachs-effect. The author finds that in the region of the spectrum which causes fluorescence and effects polymerisation of anthracene, namely about 400–225 $\mu\mu$, no Hallwachs-effect appears, whereas increased conductivity of solid anthracene is observed in this region. In this light a new photoelectric phenomenon has been discovered with anthracene and with sulphur, consisting in the emission of positive or negative ions of the solid body into the solvent under the influence of an electric field. In the same region of the spectrum solutions of anthracene in pure hexane exhibit marked increase in conductivity. Solid anthracene shows the Hallwachs-effect only with wave-lengths of less than 225 $\mu\mu$. The experimental results indicate that Byk's theory of the formation of dianthrane is inadmissible in so far as it assumes separation of electrons as the primary action. From that part of Stark's theory of fluorescence which supposes total separation of the electrons, the author's results in various instances remove experimental support. The view is advanced that photochemical processes, especially the formation of anthracene, may be regarded as a consequence of alteration in the state of vibration of the valency electrons. This view is illustrated with the help of Thiele's formula for the anthracene molecule.

T. H. P.

1186. *Absorption of Heat produced by Emission of Ions from Hot Bodies.* H. L. Cooke and O. W. Richardson. (Phil. Mag. 25. pp. 624-648, April, 1918.)—Richardson has previously pointed out [see Abstract No. 1489 (1904)] that there should be a considerable stream of energy away from the surface of a hot body which is emitting electrons or ions. When the total thermionic current is i , the rate of loss of energy is $i(\phi + 2R\theta/e)$, where ϕ is the drop of potential through which an ion would have to fall in order to acquire the energy which is equal to the heat rendered latent when the ion is emitted by the substance, R is the gas constant for a single molecule, e the charge on an ion, and θ is the temperature of the substance. Attempts to detect this loss of energy have been made by Wehnelt and Jentzsch and by Schneider [see Abstracts Nos. 1079 (1909), 1418 (1912)]. These investigators all used a lime-coated Pt-wire as source of electrons. They agree in observing a cooling effect which is generally larger than that given by the above theory. They did not, however, take the precaution to eliminate or allow for the direct disturbing action of the thermionic current on the galvanometer of the Wheatstone bridge system. There is also possibly something about the emission from lime that makes its behaviour exceptional. The experiments made by the authors were carried out with filaments of osmium as the source of emission. A diagrammatic representation of the experimental arrangement and a detailed theory of the measurement are given. The experiments afford a strong confirmation of the views about the nature of the emission of electrons from hot bodies which have been put forward by Richardson. In particular, since osmium is closely related to Pt both chemically and physically, we should expect it to have a very similar value of ϕ . The value obtained is very close to the value of the corresponding quantity which has been obtained from the converse heating effect when electrons were absorbed by Pt, and is not very different from the values of the latent heat, expressed in equivalent volts, which have been deduced from the temperature variation of the emission of electrons by Pt.

A. E. G.

1187. *Temperature of Kathode and Anode in a Geissler Tube.* B. Hodgson. (Phil. Mag. 25. pp. 458-461, April, 1918.)—A special form of discharge tube is described in which one of the electrodes has a cavity drilled so as to admit the bulb of a thermometer. Curves and tables are given showing the results obtained in air, oxygen, and CO_2 ; there is also a detailed theoretical consideration of the observed phenomena. The general results are as follows:—A linear relationship exists between the current through a vacuum tube and the heat-energy communicated to the kathode both for normal and abnormal kathode-glow, this effect being a minimum at a certain pressure for a constant current. It is possible that this minimum coincides with that found by Ebert, at which a discontinuity occurs in the relationship between pressure and width of the dark space; further experiments on this point are in progress. The ratio between the positive and negative carriers at the kathode is approximately 10:1. A linear relationship also exists between current and heat energy at the anode, though for the same pressure and current the heat communicated is much less than in the case of the kathode. The change in pressure produces much greater changes in temperature than in the kathode. The kathode-fall is able to account for the heat energy given to the kathode, but the anode-fall alone cannot do so for the anode.

A. E. G.

1188. *Stratified Vacuum Discharges.* E. Riecke. (Phys. Zeitschr. 14. p. 280, March 15, 1918.)—The stratification of the positive column in some VOL. XVI.—A.—1918.

cases, and the want of stratification in others, may be explained by the difference between the ionising potentials of the positive and negative ions. If these have a common factor, ionisation by collision will occur in definite planes. If not, it will occur in all sections of the positive column equally; and no stratification will occur. The simplest case is when the ionisation potentials for + and - ions are the same. To complete the theory, it will be necessary to determine the relation between ionisation potentials for + and - ions in the same tube. E. E. F.

1189. *Instantaneous Braun-tube Photographs.* J. Zenneck. (Phys. Zeitschr. 14. pp. 226-229, March 15, 1918. Rev. Électrique, 19. pp. 566-568, June 20, 1918.)—It has lately become possible to take instantaneous photographs of oscillographic curves by means of Braun's kathode-ray tube, owing to the increased luminosity available. The author describes an attachment to an ordinary camera suitable for taking such photographs, and reproduces some fine specimens of results, including that obtained with a damped condenser circuit of frequency 250 per sec. The fluorescent substance used was Giesel's zinc sulphide. E. E. F.

1190. *Kathodic Sputtering.* G. W. C. Kaye. (Phys. Soc., Proc. 25. pp. 198-201; Discussion, pp. 201-202, April, 1918.)—Gives an account of the volatilisation of an Al kathode in a discharge tube containing helium. The sputtered deposit on the glass indicates that, under the conditions which prevailed, the disintegration was restricted to the edges of the kathode and did not occur elsewhere. Accordingly the complete outline of the kathode (made by rolling a sheet of Al into a nearly complete cylinder) was traced out by the deposit on the walls of the tube. L. H. W.

1191. *Anode Phenomena in Vacuum Discharges.* W. G. Cady. (Phys. Zeitschr. 14. pp. 296-302, April 1, 1918.)—When small particles of oxide occur on the anode during a glow discharge, the positive column tends to concentrate upon them. With a sufficiently strong current an arc forms on the oxidised patches. Experiments were made with Cu, Hg, Fe, and Ag electrodes in nitrogen containing traces of oxygen. The nomenclature of the various stages is discussed in connection with the observations of Buisson and Fabry, Hagenbach and Veillon, and Occhialini. E. E. F.

1192. *Reflection of Electric Waves by Ionised Gases.* J. Salpeter. (Phys. Zeitschr. 14. pp. 201-208, March 1, 1918.)—Gives expressions for the dielectric constant, the conductivity, the refracting, reflecting, and absorbing powers of a gas in terms of its pressure and degree of ionisation. Shows that the conductivity of a gas for high-frequency oscillations is only a small fraction of its d.c. conductivity. The results are substantially the same as those obtained by W. H. Eccles [Abstract No. 1254B (1912)]. E. E. F.

1193. *Oscillations of the Poulsen Arc.* H. Fassbender and E. Hupka: (Phys. Zeitschr. 14. pp. 222-226, March 15, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—According to Blondel and Simon [Abstracts Nos. 1918 (1905), 1428 (1906)] the singing arc shows three varieties of oscillation. In the first there is no interruption and the current curve is very nearly a sine curve. In the second there is an extinction in the course of each period, and the p.d. rises after each extinction until the arc lights up. In the third variety the lighting-up after each extinction occurs in the opposite direction. These varieties have been demonstrated with the Blondel VOL. XVI.—A.—1918.

oscillograph for frequencies up to 10,000 \sim per sec. The authors tested the Poulsen arc up to 100,000 \sim per sec. for the same varieties of oscillation, a Braun tube serving as oscillograph. They found oscillations of the first and second types. E. E. F.

1194. *Exact Mechanical Analogy to Coupled Circuits used in Wireless Telegraphy, and a Geometrical Method of Interpreting the Equations of such Circuits.* T. R. Lyle. (Phil. Mag. 25. pp. 567-592, April, 1918).—If a horizontal beam of mass M is so supported that it can move freely in the direction of its length and from it two simple pendulums of lengths l_1 and l_2 with bobs of masses m_1 and m_2 are suspended from the beam by V suspensions so arranged that the bobs are constrained to move in the vertical plane through the axis of the beam, the system when making small oscillations is identical with a pair of coupled circuits. Taking the coupling for a pair of circuits as $M/\sqrt{(L_1 L_2)}$, where M is the mutual induction and L_1, L_2 are the self-inductions, the coupling for the mechanical system is—

$$\sqrt{[m_1 m_2 / (M + m_1)(M + m_2)]}.$$

Both mechanical and electrical systems satisfy the equation—

$$[\cos^2 \psi D^4 + (\mu_1^2 + \mu_2^2) D^2 + \mu_1^2 \mu_2^2] \phi = 0 \dots \dots \dots (1),$$

where $\sin \psi =$ coupling, μ_1 and μ_2 represent the natural periods of the circuits or simple pendulums, and D is the operator d/dt . In the mechanical system the angular displacements of the pendulums correspond to the p.d.'s across the condensers of the coupled circuits and their angular velocities represent the currents in the circuits. The coupling of the mechanical system can be altered by loading the beam. If a is written for μ_1^2 and b for μ_2^2 and a and b are drawn as sides of a triangle including an angle 2ψ , and if the equation (1) is solved in the usual way by obtaining the factors of the operator considered as a simple quadratic function, the roots of the quadratic are: $-ab/s$ and $= -ab/s - c$, where c is the closing side of the above triangle and $2s = a + b + c$, and the equation (1) reduces to $(D^2 + \omega_1^2)(D^2 + \omega_2^2)\phi = 0$, where $\omega_1^2 = ab/s$ and $\omega_2^2 = ab/s - c$. This geometrical method of presenting the solution for the resultant frequencies simplifies many of the considerations relating to coupled circuits. The method is applied to several cases, and the analogy between the mechanical and electrical systems fully worked out. The apparatus is fully described. T. P. B.

1195. *Resistance of Flat Spirals and Short Cylindrical Coils for High-frequency Oscillations.* R. Lindemann and W. Hüter. (Deutsch. Phys. Gesell., Verh. 16. 7. pp. 219-286, April 16, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—The paper is an extension of one already abstracted on the resistance of stranded cables [see Abstracts Nos. 1187 (1910) and 1187b (1911)]. The experiments are here extended to coils of copper strip. It is found that the strip shows a smaller "skin-effect" than round wire of the same cross-section. The resistance of flat spirals is also investigated, and the results show that these coils have a higher resistance than cylindrical coils, all else being equal. Coils of similar characteristics made of solid wire, strip, and stranded wire are compared. For short cylindrical coils and for spirals the resistance rises proportionally to $1/\sqrt{\lambda}$ for long wave-length (λ), and to $1/\lambda^2$ for short wave-length. The resistance r of short cylindrical coils of solid wire is given by a formula of the form $r = A/\sqrt{\lambda} + B/\lambda^2$. This holds down to a wave-length of 200 m. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1196. *Electrical Conductivity of Tellurium.* Mlle. P. Collet. (Comptes Rendus, 156. pp. 948-945, March 25, 1918.)—Three masses of polished tellurium were examined with faces of 0.5 to 2.0 mm. thickness. The crystalline orientation had no influence on the results. (1) Whilst the pressure is lower than a value P_1 (30 to 40 gm. per sq. mm.) the resistance varies irregularly owing to bad contacts. From P_1 to a pressure P_2 , the resistance remains constant. Above P_2 , the potential remaining constant, increase of pressure produces a diminution of resistance. (2) During about a minute after the passage of a current the Te is the seat of a residual e.m.f. of which the magnitude and direction depend on the nature of the contacts. (8) For periods of time exceeding some seconds the resistance is a function of the time during which the current passes. For periods of a fraction of a second the resistance has for each intensity a single definite value independent of the time during which the current flows. (4) If e is the e.m.f., i the intensity of current, the curve showing the relations of e and i starts from the origin with a somewhat high inclination. Sometimes at first it is rectilinear, then a sharp bend leads to a parabolic branch with large curvature ($i = ae^2 + be + c$). This occurs with contacts a little unstable, with electrodes not quite closely joined and made up of points. Sometimes, on the contrary, the curve has a parabolic form from the origin ($i = ae^2 + be$); the bend disappears, and for currents of about 1 amp. the two sorts of curve become parallel. J. J. S.

1197. *Variation of Resistance of Selenium due to X- and Radium-rays.* H. Guilleminot. (Comptes Rendus, 156. pp. 1155-1157, April 14, 1918.)—The author shows that, under X- and γ -rays, the resistance of selenium falls by nearly 25 % in some cases, the resistance taking several minutes to come to its final value. A table of quantitative results is given. E. M.

1198. *Light-radiation and the Telephone.* O. Grottrian. (Ann. de Physik, 40. 4. pp. 812-814, April 15, 1918.)—The paper continues the work of one previously abstracted [see Abstract No. 676 (1918)]. It is here shown that the effect there referred to is due to a change in the permeability of the iron of the membrane. Experiments are described showing that the effect is not due to the bending of the membrane by heat. The direction of the induced current is not always the same. This is due to the different magnetic state of the membrane at the outset. The question whether ultra-violet radiation causes any effect is not yet settled. T. P. B.

1199. *Measurements of Inductance.* A. O. Allen. (Phil. Mag. 25. pp. 520-584, April, 1918.)—In null methods of inductance measurement there is a marked difference in the behaviour of the galvanometer, according to whether the balance is continuous or merely aggregate. This was pointed out in 1888 by Rayleigh (B. A. Report), who also showed that two conditions must be fulfilled if the balance is to be continuous. In the present paper it is further shown that these two conditions are sufficient in all cases. When the balance is not a continuous one the duration of the flow through the galvanometer in the two directions is calculated. Most of the methods for measuring inductances are considered, and the conclusion seems to be that far too much has been made of the importance of a continuous balance, and that unsteadiness of the needle is in many cases attributable to the residual charge of any condenser in use, or similar capacity effect. F. E. S.

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1200. *The Silver Voltameter.* G. D. Buckner and G. A. Hulett. (Amer. Electrochem. Soc., Trans. 22. pp. 867-888, 1912.)—It was found that the slightest traces of impurities, such as dust and organic matter, so affected a silver nitrate solution that it gave abnormally heavy deposits. Particular attention was therefore paid to preparing a reproducible electrolyte. It was necessary to take unusual precautions in preparing all materials, and the vessels used were of quartz, gold, and platinum. Silver nitrate was obtained from "atomic-weight" silver and pure nitric acid; with this a solution was prepared which contained exact equivalents of Ag and NO₃. Kahlbaum's commercially pure AgNO₃, recrystallised and fused, gave a deposit 0.009 per cent. heavier than that obtained with this normal electrolyte, and other solutions yielded distinctly heavier deposits. Deposits on gold and on platinum were made, the deposits on gold being always the heavier; the average excess being 12 parts in 100,000. With commercially pure AgNO₃ solution the Rayleigh form gave a deposit 0.086 per cent. heavier than normal. Experiments with porous-cup voltmeters showed that if the anode liquid comes into contact with the kathode a deposit heavier by 0.019 per cent. is obtained.

F. E. S.

1201. *Sensitive Electrometer.* C. Müllly. (Phys. Zeitschr. 14. pp. 287-240, March 15, 1918.)—In order to utilise the very feeble directive force of Wollaston fibres of diam. 8 to 7 μ it is essential that the period and damping should not be great. To reduce the moment of inertia the vanes of the electrometer needle are bent down, and fit in between vertical cylindrical quadrants which take the place of the horizontal quadrants. The dimensions selected are: Height of quadrants, 12 mm.; external diam. of inner quadrants, 8 mm.; internal diam. of outer quadrants, 16 mm.; diam. of needle, 12 mm.; play of needle, 4 mm. The sensitiveness may be varied slightly by raising or lowering the needle. With a Wollaston fibre 5 μ in diam. and the needle at 105 volts, the instrument gives 45,000 scale divisions per volt on a scale at 8 m. The period is 10 to 17 secs., and the needle reaches its final position after about 8 oscillations.

E. E. F.

1202. *Vibration Galvanometers with Unifilar Torsional Control.* A. Campbell. (Phys. Soc. Proc. 25. pp. 208-204; Discussion, pp. 204-205, April, 1918.)—In the Campbell vibration galvanometer, the control being elastic (bifilar), the final tuning is brought about by altering the tension of the wire. The author finds that the torsional rigidity of a phosphor-bronze strip, when under tension, is considerably increased as the tension is raised [see also Abstract No. 605 (1918)]. He has used this new system of unifilar tuning both in the moving-coil and moving-iron vibration galvanometers, and finds it very convenient; in the moving-coil instrument minute hooks on the ends of the strips engage in contact-hooks at the top and bottom of the coil, which is easily detachable. With a mirror of 15 sq. mm. area, at 100 \sim per sec., a sensitivity of 50 mm. at 1 m. per microamp. can be obtained, the effective resistance being about 700 ohms. The anomalous behaviour of the phosphor-bronze strip is attributed by Peeling to overstrain during the process of manufacture. In the discussion, C. H. Lees remarked that it seemed natural for a strip to behave like a bifilar. The Author, in reply, attributed the behaviour of the strip to bifilar action in the case of short strips, but did not consider this the whole explanation in the case of long strips.

W. C. S. P.

ALTERNATING CURRENTS AND MAGNETISM.

1203. *The Hysteresis Loop and Index.* W. M. Thornton. (Electrician, 71. pp. 214-217, May 16, 1918.)—The paper is a brief analysis of the forms of electric and magnetic hysteresis loops. It is found that a magnetic loop formed of curves, taken to be the same on both the rising and falling sides, agrees as closely with experimental results in alternating fields as the loops obtained by the point-to-point method, and that the mean of the indices corresponding to these agrees with the Steinmetz coefficient 1.6, defined by $W = \eta B^{1.6}$, very closely, W being the energy dissipated per cycle and B the max. flux-density. The physical meaning of an index 1.6 is shown to be that the residual flux is proportional to the max. number of molecular magnets per cm. length ranged in line with the field per cycle, and the slightly higher index observed is explained by a linear polarisation in weak fields, giving rise to a coercive force proportional to the max. flux-density—that is, to the closeness of packing of molecules which are ranged into line with the field in a plane at right angles to it. **L. W. Wild, W. M. Thornton.** (Ibid. 71. p. 269, May 23; 824, May 30, and pp. 862-864, June 6, 1918.)—In correspondence following the appearance of Thornton's paper, it is stated by Wild that the hysteretic index may reach values much higher than 2.5; but this is contradicted by Thornton. G. E. A.

1204. *Hall-effect.* J. Koenigsberger and G. Gottstein. (Phys. Zeitschr. 14. pp. 282-287, March 15, 1918.)—The Hall-effect fits into the electron theory of metals satisfactorily on the whole, although special assumptions have occasionally to be made. These are, however, not more unreasonable than those which have to be made in the kinetic theory of gases. Beattie's rule that the Hall-effect and the thermoelectric force vary correspondingly points to a connection between magnetic properties, thermoelectricity, and electronic pressure. If we explain the occasionally reversed Hall-effect by assuming an internal field opposed to the magnetising field, we may picture electrons entering the atomic fields and having their motion reversed by semicircular swings. This would also imply a difference of sign in the thermoelectric force with respect to the normal metal, since the electronic pressure would be practically negative. This disposes of one of the difficulties of the electron theory. [See Abstract No. 840 (1901).] E. E. F.

1205. *Magnetic Properties of Certain Solid Hydrates of Copper and Chromium.* Mlle. E. Feytis. (Comptes Rendus, 156. pp. 886-889, March 17, 1918.)—The various molecules of water present in the hydrates of copper sulphate are not similar as regards their magnetic relations [see Abstract No. 1729 (1911)]. The same is now found to be the case with the hydrates of cupric chloride. The magnetic susceptibility of the anhydrous chloride is markedly lower than that calculated from the value for $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, and very nearly equal to that calculated for $\text{CuCl}_2 \cdot \text{H}_2\text{O}$. The structures of the two salts, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ may hence be expressed thus: $(\text{CuSO}_4, \text{H}_2\text{O}) + 4\text{H}_2\text{O}$ and $(\text{CuCl}_2, \text{H}_2\text{O}) + \text{H}_2\text{O}$. Measurement of the specific and molecular susceptibilities of a number of anhydrous and hydrated double salts of cupric and other chlorides shows that here too the property is additive in no single case. Further, the molecular susceptibilities of the anhydrous double salts, which, like cupric chloride, are brown, vary little from a mean value of 1290×10^{-6} , whilst those of the green or blue hydrated salts have values of about 1400×10^{-6} ; these results tend to confirm Wiedemann's

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observation that compounds of the same type have the same molecular susceptibility. The lowering of the value by loss of water is probably connected with modifications in the constitution of the salts. The attribution of different rôles to the various molecules of water in the green and violet hydrates of chromic salts is not justified by their magnetic susceptibilities. Thus, the isomeric green chloride $[\text{CrCl}_2(\text{H}_2\text{O})_4] \text{Cl} + 2\text{H}_2\text{O}$, and the violet one $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_2$, have the same susceptibility. Also, with the different violet and green hydrates of chromic sulphate, the susceptibility is an additive property in all cases; additivity is also observed with chromium-potassium alum.

T. H. P.

1206. *Variation of Magnetic Susceptibility with Temperature. II. Aqueous Solutions.* A. E. Oxley. (Cambridge Phil. Soc., Proc. 17. No. 1. pp. 65-89, Feb. 14, 1918.)—The relation between temperature and magnetic susceptibility of aqueous solutions of ferric chloride, ferrous sulphate, and ferric nitrate has been investigated. Assuming the independence of the susceptibility on the intensity of the magnetic field and the formation of molecular complexes which contain water of hydration and have compositions varying with the temperature according to van Laar's theory, the author derives for the susceptibility χ , the formula, $\chi = A/\theta + B + C\theta$, or, for dilute solutions, $\chi = A/\theta + B$, where θ represents the absolute temperature. The susceptibility-temperature curves for the above solutions are approximately hyperbolic and correspond well with the above formulæ. A 2.28-normal ferric chloride solution, which gave results expressed by $\chi = A/\theta + B$, was shown to possess an abnormal constitution, evidence of this being given by abnormal variation of its viscosity with the temperature and by determinations of the molecular depressions of the freezing-point. [See Abstracts Nos. 988, 1109 (1912).]

T. H. P.

1207. *Magnetic Storms and Hysteresis Phenomena.* J. Bosler. (Comptes Rendus, 156. pp. 1419-1421, May 5, 1918.)—The hypothesis that variations in earth currents are the cause of magnetic storms is shown to account in a general way for certain simultaneously recorded curves of horizontal force and east-west earth current, if allowance be made for hysteresis effects produced by the magnetic substances within the earth.

R. C.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1208. *Hard X-rays.* F. Dessauer. (Phys. Zeitschr. 14. pp. 246-247, March 15, 1918.)—The author finds that the hardest X-rays are furnished by the first portion of the discharge of the induction coil, probably owing to the ionisation of the gas being then a minimum. He constructs an apparatus giving hard rays only. It is worked with the high potentials of a transformer, the X-ray tube being in circuit only at the max. potential, and cut out during the rest of the discharge, which is sent through a high resistance.

E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1209. *Preparation of Barium.* C. Matignon. (Comptes Rendus, 156. pp. 1878-1880, May 5, 1918.)—Barium may be prepared conveniently and cheaply by heating at 1200° a mixture of anhydrous baryta (8 mols.) with commercial silicon (1 atom) of a purity of 90 % or upwards. T. H. P.

1210. *Further Applications of Positive Rays to the Study of Chemical Problems.* J. J. Thomson. (Cambridge Phil. Soc., Proc. 17. p. 201, April, 1918. Electrician, 70. p. 765, Jan. 24, 1918.)—Two samples of gases obtained from the residues of liquid air are examined. One sample, treated so as to contain the heavier gases, is found on analysis to contain xenon, krypton, and argon. There are no lines on the photograph unaccounted for, hence it is concluded that there are no unknown heavy gases in the atmosphere in quantities comparable with the known gases. The other sample, treated so as to contain the lighter gases, is found to contain helium, neon, and, in addition, a new gas with the atomic weight 22. The relative brightness of the lines for this gas and for neon shows that the amount of the new gas is much smaller than that of neon. The new gas, of atomic weight 8, which this method of analysis has shown to be present in the tube under certain conditions, is also investigated. The gas had occurred sporadically in the tube from the time of the earliest experiments but its appearance could not be controlled. After a long investigation into the source of this gas, it is found that it always occurs in the gases given out by metals when bombarded by cathode rays: a trace of helium is also usually found on the first bombardment. The metals used are Fe, Ni, Zn, Cu, Pb, and Pt. The gas is also given off by calcium carbide. Various experiments illustrate the stability of the gas. [See Abstract No. 1870 (1912).] A. E. G.

1211. *Effect of High Pressures on the Physical and Chemical Behaviour of Solids.* J. Johnston and L. H. Adams. (Amer. Journ. Sci. 85. pp. 205-258, March, 1918.)—In considering the influence of compression on solid systems, it is necessary to distinguish between the effects of uniform and non-uniform pressure. The former has a comparatively slight effect on the melting-point, which is usually raised by an amount which is seldom greater than 10° and never greater than 80° per 1000 atmos.; its effect on solubility is small and practically negligible compared with the influence of temperature. Uniform pressure tends to further those reactions which are accompanied by decrease of volume, but it does not follow that it will induce these or other reactions, since the occurrence of a reaction depends primarily on its velocity under the prevailing conditions and there is evidence indicating that velocity of reaction is not greatly affected by uniform pressure. The effects of non-uniform pressure are of much greater importance, the melting-point being always lowered and the solubility always raised by amounts many times as great as with uniform pressure. Indeed, on the assumption that permanent deformation of a crystalline aggregate is conditioned by a real local melting at the parts carrying the bulk of the load at any moment, the pressure required to cause melting at ordinary temperatures is found to be well within the bounds of probability. This is regarded as the cause of
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most of the phenomena occurring when solid systems are compressed. Discussion of the results obtained from the above standpoint leads to the following conclusions:—(1) The compression required to cause crystalline solids to flow or to weld together depends mainly on the melting-point, heat of fusion and density of the substance and the experimental temperature. There is thus a rough parallelism between ease of flow and melting-point, the substances with the highest melting-points being those which at any fixed temperature require the greatest pressure to weld them. (2) In general, compression does not cause crystallisation of a material or the transformation of one form into another; it does so, however, where the other conditions are such that the velocity of transformation is appreciable, and it further causes a partial transformation wherever the conditions are such that partial melting occurs. (3) With uniform pressure a chemical reaction takes place only at the surfaces of contact, so that a small total amount of compound is formed. When, however, the compression is not uniform there is a renewal of the surfaces and the reaction hence proceeds further; such renewal is the result of a direct abrasive action and may also be advanced by a melting and flowing-away of the reaction product, provided its melting pressure is attained. Thus non-uniform compression has precisely the same effect as grinding the reacting substances together. (4) Several of the criteria applied by Spring (1880–1888) to determine the condition of compressed systems are insufficient. For example, nothing is at present known concerning the equilibrium in the solid system, $\text{BaSO}_4 + \text{Na}_2\text{CO}_3 = \text{Na}_2\text{SO}_4 + \text{BaCO}_3$. (5) In the formation of alloys the conditions are the same as those affecting chemical reaction. Where solid solutions are possible, the intimate contact produced by compression favours diffusion, but does not seem to promote the formation of solid solutions in any other way. These considerations serve to harmonise the outstanding discrepancies in the literature dealing with the effects of high pressure on solids.

T. H. P.

1212. *Crystallisation of Steel*. F. Giolitti. (Accad. Sci. Torino, Atti, 48, 10a. pp. 418–488, 1912–1918.)—The author describes experiments which lead him to take a somewhat different view from that of Belaiew [Abstract No. 1280 (1912)] as to what occurs during the crystallisation of steel. He concludes that there are two successive processes of crystallisation: (1) the formation of mixed crystals of the fused metallic mass, and (2) the segregation of the ferrite or cementite from the solid solution. Contrary to Belaiew's results, slow cooling is found to favour the formation of Widmanstätten's figures in steel containing about 0.82 % carbon and heated to 1000° C. for 8 hours, while rapid cooling renders them less perfect. Belaiew's hypothesis to explain the formation of Widmanstätten's structure and his theory of secondary crystallisation are not accepted.

W. H. Sr.

1213. *Vacuum-furnace Metallurgy*. C. G. Fink. (Amer. Electrochem. Soc., Trans. 21. pp. 445–458; Discussion, pp. 458–461, 1912.)—An account of experiments made since 1907, when cobalt ores had been discovered at Cobalt, in Arsem vacuum furnaces at less than 8 mm. of mercury in the General Electric Research Laboratories at Schenectady and Harrison. Arsenic would also distil over at atmospheric pressure, but silver would be lost then, and the value of the ores depends practically on their silver-contents. The ores, also stibnite, Sb_2S_3 , are also heated with additions; of these calcium carbide, produced in the furnace from carbon and calcium carbonate, answers best—better in the case of stibnite than iron.

H. B.

1214. Liquidus Curves and Equilibrium Diagram of the Ternary Series Aluminium-Copper-Zinc (Rich Copper Alloys). H. C. H. Carpenter and C. A. Edwards. (Rev. de Métallurgie, 10. pp. 429-450, March, 1918.)—The method of graphically representing the equilibrium of a ternary series by means of a space model has been dealt with, particularly as regards its application to systems in which there is either complete insolubility or partial solubility in the solid. Alloys containing 40 to 100 % Cu, up to 60 % Zn and 16 % Al have been prepared and their cooling and heating curves studied between 400° C. and the point of solidification. The results of the thermal and microscopic examinations have been summed up by the construction of a model built up in sections corresponding to the existence of alloys of similar constitution, e.g. α , β , γ , $\alpha + \beta$, and so on. The liquidus shows that there is no ternary compound formed in the area studied and gives no definite indication of the existence of a ternary eutectic. At 700° C. the β constituent appears to undergo a polymorphic change and the $\beta \rightarrow \alpha + \gamma$ inversion falls in a smooth curve on the Cu-Al side to 470° C. on the Cu-Zn side and at the same time appears to fall off in intensity. Effects of annealing and quenching on the microstructures have been studied and are illustrated by typical photomicrographs. The practical bearing of the results is briefly discussed at the end of the paper. F. C. A. H. L.

1215. Aluminium Brasses. L. Guillet. (Rev. de Métallurgie, 10. pp. 468-465, March, 1918.)—The author points out that the work on the coefficient of equivalence in special brasses which Carpenter and Edwards [see preceding Abstract] have attributed to Cavalier should have been attributed to him [Abstract No. 1088 (1910)]. The coefficient of equivalence is not so simple a value as was originally thought; for although alloys containing 86 % Zn and 9.4 % Al respectively are microscopically equivalent, the Al alloy has the better mechanical properties. F. C. A. H. L.

1216. Influence of Other Metals on the β Constituent of Copper-Zinc Alloys. H. C. H. Carpenter. (Rev. de Métallurgie, 10. pp. 457-462, March, 1918.)—The author has previously pointed out [Abstract No. 1457 (1912)] that below 470° C. the β constituent of copper-zinc alloys is to be regarded as a minute complex of $\alpha + \gamma$ particles. For the large, irregularly shaped polyhedra of pronounced reddish-yellow colour occurring in alloys of about 52 % Zn the name "apparent β " is suggested. The effect of an added metal on the inversion may be brought about in several ways: (1) it may be quite or practically insoluble in apparent β (Bi, Pb, Cr) but exert its influence by virtue of great power of crystallisation; (2) it may possess limited solubility (Sb, Sn, Al, V, Si, Fe) and either displace the eutectoid composition towards the γ side or affect the temperature of the inversion, and (3) it may be very or completely soluble (Mn, Ni) and lower the temperature of the inversion to below the ordinary temperature—a highly desirable result, because β would then be the stable phase at ordinary temperatures and the development of brittleness would be prevented. Investigation of the effects of the metals enumerated above has shown that the effects of Bi, Pb, and Cr on the stability of apparent β are so slight as to be negligible for the amounts present in industrial alloys. All the partially soluble metals appear to assist the inversion by displacing the alloy from the eutectoid composition to the γ side. V, Si, Sn, Sb, and Al are particularly active in this respect, while Fe is least active on account of its lowest solubility. Ni is somewhat irregular in action, but generally aids the $\alpha + \gamma$ separation, while

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Mn is almost without action. Heating- and cooling-curves of alloys containing approximately 8 % of Cr, Fe, and Mn respectively show that the temperature of the inversion is practically unaffected. From the practical point of view, the results show that it is impossible to prevent the inversion by the addition of a third element, but, on the other hand, the stability of the β structure is increased by the removal of impurities as far as possible.

F. C. A. H. L.

1217. Chemical Properties and Relative Activities of the Radio-products of Thorium. H. N. McCoy and C. H. Viol. (Phil. Mag. 25. pp. 388-359, March, 1918.)—The paper gives results of a large number of experiments on the chemical reactions of all the longer-lived radio-active products of thorium. From a knowledge of the chemical properties methods are worked out for the separation of the various products from inactive substances and from one another, and for the preparation of several of the products completely free from radio-active impurities. The relative activities of $\text{Th}(B + C + D)$ and $\text{Th}(X + \text{Em} + A)$ was determined by preparing ThX entirely free from $B + C + D$ and determining its change of activity with time. Knowing the periods of each of the substances the α -ray activity of $B + C + D$ was found to be 0.427 of that of $X + \text{Em} + A$. Similarly it was found that the products of radio-thorium are 5.28 times as active as the Radio-Th itself. These ratios are in good agreement with those calculated on the assumption that the total ionisation of an α -particle is proportional to the $2/3$ power of its range. The periods of ThX , ThB , and ThC were found to be 8.64 days, 10.60 hours, and 60.8 mins. respectively.

E. M.

1218. Spontaneous Variations of Concentration. E. v. Schweidler. (Phys. Zeitschr. 14. pp. 198-200, March 1, 1918.)—Attributes the deviations of Svedberg's observed variations of concentration in radio-active solutions [Abstract No. 780 (1918)] from the values predicted by Langevin, Smoluchowski, and Lorentz, to some disturbance affecting many atoms simultaneously, as when swarms of radio-active atoms adhering to adsorption nuclei moving through the solution enter the "effective area" in an irregular manner, or when in a gas containing emanation a rapidly changing distribution of the radio-active deposit is brought about by irregularly varying electric fields. The actually observed values do not exceed the theoretical values by more than 48 per cent.

E. E. F.

1219. Energy Absorbed and the Amount of Reaction Taking Place in a Photochemical Reaction. M. Boll. (Comptes Rendus, 156. pp. 691-694, March 8, 1918.)—A trough, with a quartz bottom and containing a solution of chloroplatinic acid, is placed in the path of a ray of monochromatic light ($\lambda = 2536$) falling on another trough, also containing a solution of chloroplatinic acid. The amount of photochemical action which takes place in each solution can be determined by measuring the electrical conductivities of the solutions [see Abstract No. 769 (1912)]. The amount of reaction taking place in the lower trough is a measure of the light which has come through the upper trough and therefore of the light absorbed in the upper trough. The amount of reaction in the upper trough is known from the electrometric measurements, and therefore the photochemical action of the light absorbed can be determined. It is found that when the same solution is both absorbing light and undergoing a chemical reaction, the energy of the emergent light decreases in accordance with the laws of Lambert and Beer; that is, it

is an exponential function of the thickness of the absorbing layer and of the concentration. There is, however, no proportionality between the amount of reaction taking place and the energy absorbed, as there should be according to the law of Grotthus; the amount of reaction is extremely small, even when the amount of energy absorbed is relatively considerable. T. S. P.

1220. Ionic Size in Relation to Molecular Physics, together with a New Law relating to the Heats of Formation of Solid, Liquid, and Ionic Molecules. W. R. Bousfield. (Roy. Soc., Proc. Ser. A. 88. pp. 147-169, March 81, 1918.)—In a former paper it was shown that ionic volumes (derived from mobilities) and solution volumes were connected by an empirical linear relation $EV_v = a - bI_v$. In the present paper a new empirical relation is established of the form $D^{-1} = p - qN(I_v - K)$, where D is the effective molecular freezing-point depression, i.e. $\Delta/N(1+\alpha)$. In the former paper the experimental data were given for KCl and NaCl, and in the present paper for LiCl, which data determine the constants a , b , p , q , for each salt. It is shown that we can express in terms of these constants—(1) The factor required to reduce arbitrary ionic volume units to absolute units; (2) the volume of the ionic nuclei; (3) the volume and mean density of the "watery atmospheres" associated with the ions. It is shown for a group of fourteen solid and liquid salts and acids that their heats of formation are given by the expression $\sum \delta V + H_1 + H_2$, where δV is the reduction of volume (or contraction) which takes place on combination, and H_1 and H_2 are constants for the elements of which they are composed. It is found that the heats of ionisation of the three salts may also be expressed under the same law as

$$\sum \delta V + H_1 + H_2 + 1.8n - 29$$

where δV includes volume-change of combined water as well as of ionic nuclei, n is number of molecules of combined water and -29 is a constant which represents endothermic changes involved in ionisation. T. M. L.

1212. Conductivity, Dissociation and Temperature-coefficients of Conductivity of Salts, as Conditioned by Temperature, Dilution, Hydration and Hydrolysis. E. J. Shaeffer and H. C. Jones. (Amer. Chem. Journ. 49. pp. 207-258, March, 1918.)—Conductivity increases with temperature and dilution. As a rule temperature-coefficients in conductivity units increase with rise in temperature. Salts strongly hydrated have large coefficients, those not strongly hydrated have small coefficients. The temperature-coefficients are of the same order of magnitude for salts having approximately the same hydrating power. They increase with dilution, and the increase is greatest for those substances with large hydrating power. With but one exception dissociation was found to decrease with rise in temperature. Temperature coefficients in per cent. decrease with rise in temperature. T. M. L.

1222. Normal and Abnormal Cases of Specific Volume of Binary Liquid Mixtures. H. S. Van Klooster. (Amer. Chem. Soc., Journ. 85. pp. 145-150, Feb., 1918.)—The specific volume data for mixtures of paranitrotoluene and carbon disulphide are not really abnormal if calculated for an extrapolated value for the specific volume of (strongly-undercooled) liquid paranitrotoluene. The max. deviation between the observed and calculated specific volume is then only 0.008, being rather less than the max. difference for mixtures of carbon disulphide and chloroform. A real abnormality is found in
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mixtures of chloroform and ether, which appear to form a compound $\text{CHCl}_3 + \text{C}_4\text{H}_{10}\text{O}$. This is indicated by a max. contraction and rise of temperature on mixing, as well as by abnormal viscosity curves. T. M. L.

1223. *Slow Ions in Liquid Dielectrics.* H. J. van der Bijl. (Deutsch. Phys. Gesell., Verh. 15. 4. pp. 102–108, Feb. 28, 1918.)—The author discusses the formulæ for the motion of ions in very viscous media, with special reference to ions produced by radium rays and by ultra-violet light, in vaseline and in aniline. T. M. L.

1224. *Galvanic Cells of Water-insoluble Organic Liquids and Aqueous Solutions.* R. Beutner. (Amer. Chem. Soc., Journ. 85. pp. 844–852, April, 1918.)—Preliminary communication on a new kind of e.m.f. The concentration cell: $-\text{Ag}|\text{AgNO}_3 \text{ diluted} \dots \text{AgNO}_3 \text{ concentrated}|\text{Ag}+$ may also be arranged $+\text{AgNO}_3 \text{ dil.}|\text{Ag}|\text{AgNO}_3 \text{ conc.}-$. J. Loeb and the author found that animal and vegetable skins behaved like metals in the latter type of cell; and the author now states that certain organic substances insoluble in water act similarly. Thus the combination $-m/10\text{NaCl}|\text{salicylic aldehyde}|\text{m}/1250 \text{NaCl}+$ yields 0.075 volt. The cell is therefore reversible for the Na-ion; but the reversibility is not confined to this Na-ion (as it would be to the Ag-ion in the ordinary case), for the NaCl may be replaced by KCl, CaCl_2 , Na_2SO_4 , CuSO_4 , NH_4Cl , AlCl_3 , etc. Explaining the phenomena on Nernst's lines, the author considers that the solution should contain a strong acid (salicylic) likely to react with the salt KCl, and that the concentration of the resulting K-salicylate should be greater than the concentration of KCl in water. Similarly aniline should behave like a chlorine-electrode; and this is found to be the case. The phenomena appear important for the e.m.f. of living tissues, the migration of small particles through membranes and narrow tubes and the precipitating action of salts on colloids. H. B.

1225. *Electro-osmotic Potential-differences caused by the Movement of Solid Particles in Liquids.* J. Stock. (Acad. Sci. Cracovie, Bull. 8a. pp. 181–144, March, 1918.)—The apparatus used consisted of a 200 cm. long glass tube of 1.5 sq. cm. area. In the tube were five small side-tubes, into which were sealed Pt-wires in such a way that they could not come into contact with quartz powder falling through the liquid (nitro-benzene) contained in the tube. The two outer electrodes were connected with a sensitive Deprez-d'Arsonval galvanometer, so that the relative conductivity of the liquid for different quantities of quartz powder could be determined directly, a potential of 120 volts being used in order to diminish as much as possible the error due to polarisation. The three intermediate electrodes were connected in pairs with the one set of quadrants of a Dolezalek electrometer, and to earth, and served for the potential measurements. The other pair of quadrants were earthed; the potential applied to the needle was 20–100 volts. The whole tube could be turned through any angle round a horizontal axis fixed in the wall; it was covered with wire gauze, which was earthed, in order to do away with electrostatic disturbances. The author develops the theory of Smoluchowski for the phenomenon in question to meet the case of the particular experimental method used and finds an agreement between theory and experiment. From the results he is enabled to calculate the p.d. occurring in the electrical double layer, and also the thickness of the layer, the values being 0.058 volt and 4.5×10^{-7} cm. respectively, which values are in agreement with those previously found by the author [Abstract No. 498 (1918)]. T. S. P.

1226. Prevention of Iron Corrosion by Counter E.M.F. J. K. Clement and L. V. Walker. (Amer. Electrochem. Soc., Trans. 22. pp. 198-208; Discussion, p. 208, 1912.)—The experiments were made at the Pittsburg station of the Bureau of Mines. Couples of iron and carbon are immersed in dilute sulphuric acid and currents from accumulators passed from the carbon to the iron. These currents prevent the formation of ferrous ions; the corrosion is much accelerated by passing oxygen through the electrolyte, which prevents the polarisation by hydrogen, and by stirring. The supply of hydrogen by the current should be equivalent to the oxygen supply near the kathode; the current density required for this purpose can be calculated from the loss of the unprotected iron under the same conditions. H. B.

1227. Corrosion of Iron by Sulphuric Acid in Presence of Other Substances. O. P. Watts. (Amer. Electrochem. Soc., Trans. 21. pp. 837-858; Discussion, pp. 858-858, 1912. Electrician, 71. pp. 560-562, July 11, 1918.)—The rate of corrosion of iron in sulphuric acid—important for the pickling process—is strongly influenced by the presence of other substances. Arsenic and tin, also chromium and mercury, retard the corrosion, which effect is ascribed to overvoltage. A retarding influence is also exercised by hydrochloric acid, alkali chlorides, etc. Chromic acid, dichromates (I), nitrates, copper sulphate, on the other hand, are said to accelerate corrosion. The experiments are preliminary, and much evidently depends, as was pointed out by A. S. Cushman, E. B. Spear, and W. A. Patrick, on the relative concentrations, also as regards the protection afforded by arsenic. H. B.

1228. Influence of Various Elements on the Corrodibility of Iron. C. F. Burgess and J. Aston. (Amer. Electrochem. Soc., Trans. 22. pp. 241-250; Discussion, pp. 251-258, 1912.)—The effect of small proportions of various elements on the corrodibility of electrolytic iron was investigated by exposing strips of the metals to the action of (1) weather conditions for 162 days, and (2) 20 per cent. sulphuric acid for one hour. The great majority of the alloys exhibit greater durability than the electrolytic iron, thus refuting the popular belief that any element added to iron increases its corrodibility by furnishing galvanic couples. Certain forms of pure commercial iron are also less corrodible than electrolytic iron. Aluminium has little influence on the liability of iron to corrode, and there is no particular merit in the use of arsenic alloys in this respect; further, As produces brittleness and weakness and also high magnetic qualities, but is difficult to add. Cobalt diminishes corrosion, but has no advantage over the cheaper nickel. Addition of copper results in marked decrease of the rate of attack of iron by acid, and possibly by atmospheric conditions; this effect may be due to the solution of iron and formation of a film of copper, which protects the underlying metal. Corrosion by acid is apparently unchanged by the presence of lead (0.061 per cent.) whilst atmospheric corrosion seems to be retarded.

With manganese (0.5-10.42 per cent.) the results obtained are inconsistent, but the atmospheric tests appear to indicate slight increase of corrosion with increase of Mn-content, though in all cases the corrosion is less than for electrolytic iron alone. Nickel gives good results in both the acid and atmospheric tests, there being a general tendency for increased resistance with increased proportion of Ni. The highest resistance found is with 10 per cent. or more of Ni; but such alloys are not generally applicable in practice, owing to their cost and undesirable physical properties. An alloy containing 0.017 per cent. of selenium exhibits low resistance to corrosion either by acid or in the air.

The addition of silicon in the usual proportions seems to be disadvantageous both to acid and to atmospheric corrosion. With silver (0.28-0.69 per cent.) the results are closely compared with those obtained with the iron alone. With alloys containing tin (0.28-1.56 per cent.) the resistance towards acid is particularly good with small proportions of tin, but shows marked increase with larger proportions; the atmospheric tests show nothing particularly noteworthy. Addition of tungsten (0.4-28.86 per cent.) gives good, but irregular, results in the acid tests; the same is true in regard to the atmospheric tests, in which an apparent tendency towards decreased corrosion with increased tungsten content is observed.

T. H. P.

1229. Inclusions in Electrolytic Silver and their Effect on the Electrochemical Equivalent of Silver. J. S. Laird and G. A. Hulett. (Amer. Electrochem. Soc., Trans. 22. pp. 845-865; Discussion, p. 865, 1912.)—After a discussion of the various attempts which have been made to determine the amount of inclusions, if any, in electrolytic silver, the authors describe a new method which they have adopted. It consists in dissolving the electrolytic silver in molten tin at 400°-500°; at these temperatures tin is readily oxidised, not only taking up oxygen rapidly and completely, but also reducing oxides of nitrogen to nitrogen. It also decomposes silver nitrate, the silver and oxygen being retained and the nitrogen liberated quantitatively. The quantities of gases evolved are small and require a special method of analysis, the one adopted being that of fractional condensation at low temperatures. Any gas remaining uncondensed consists of nitrogen, which can only have come from the decomposition of silver nitrate, and is therefore taken as a measure of the silver nitrate originally present in the silver crystals. Any other gases which would be likely to occur would be oxidised to water-vapour and CO₂ and condensed. The results showed that the deposits on gold cups contained slightly less water than the deposits on platinum cups, but that the other impurities were considerably greater in the deposits on gold. The average amounts of impurities per gm. of silver deposited were of the order: 0.042 gm. of water, 0.0042 gm. of CO₂, and 0.0058 gm. of silver nitrate. The CO₂ is due probably to some colloidal silver compound, possibly silver carbonate, which is present in the supposedly pure silver nitrate. The results show that silver deposited from the purest silver nitrate solution, kept free from filter paper or anode liquor, contains at least 5 parts in 100,000 of impurity, and may contain several times this amount in deposits formed in the Rayleigh coulombmeter. [See Abstract No. 1017 (1908).]

T. S. P.

1230. Electrochemical Equivalent of Cadmium. J. S. Laird and G. A. Hulett. (Amer. Electrochem. Soc., Trans. 22. pp. 885-898; Discussion, pp. 898-896, 1912.)—Comparison of the masses of different ions liberated from solution by the passage of the same quantity of electricity would be, theoretically at least, the simplest and most direct method of comparing equivalent weights. Such a comparison has been made in very few cases with any degree of accuracy, mainly on account of two difficulties: (1) The solution of a metal in contact with the metal often contains two or more kinds of kathions, all of which assist in carrying the current; (2) in most cases it is difficult to obtain a deposit which is pure and capable of being freed from the electrolyte without loss or oxidation in washing. These difficulties can be obviated by using a cadmium salt (the sulphate) and depositing the Cd at a mercury kathode contained in an amalgamated Pt cup [compare

Hulett and Perdue, Abstract No. 816 (1911)]. Under these conditions, using an apparatus so designed that anolyte and catholyte are prevented from mixing, the authors find 112.81 ± 0.01 as the atomic weight of Cd. This degree of accuracy has not been previously attained with any form of coulombmeter except the silver coulombmeter, using silver nitrate as electrolyte.

T. S. P.

1231. *Electrolysis of Crystalline Compounds. I. Silver Iodide.* G. Bruni and G. Scarpa. (Accad. Lincei, Atti, 22. pp. 488-448, April 6, 1918.)—Experiments on the electrolysis of AgI at temperatures between 160° and 400° C. using silver electrodes about 2 mm. thick, inserted in the fused electrolyte, and a current of 0.1 amp., show that the quantity of Ag passing from the anode to the cathode obeys Faraday's law. It is concluded that any metallic conductivity possessed by the iodide cannot be more than a very small fraction of the total conductivity.

W. H. St.

1232. *Co-precipitation of Copper and Carbon by Electrolysis.* E. B. Spear, C. Chow, and A. L. Chesley. (Amer. Electrochem. Soc., Trans. 22. pp. 277-280, 1912.)—It is shown that when solutions of copper sulphate, containing nitric acid and varying quantities of gelatine, are electrolysed, using a rotating cathode and current densities varying from 8.6 to 10 amps./dm.², carbon can be precipitated with copper at the cathode. The evidence indicates that at least some of the carbon is in a free state in the deposit. The authors conclude that an oxidising action, due to secondary reactions, takes place at the cathode. [Compare Abstract No. 290 (1910).]

T. S. P.

1233. *Effect of Addition Substances in Lead Plating Baths.* F. C. Mathers and O. R. Overman. (Amer. Electrochem. Soc., Trans. 21. pp. 818-882; Discussion, pp. 882-885, 1912.)—This paper gives the results of experiments to find the best addition substances for use in lead plating and refining baths. The following classes of compounds were tried: Inorganic, essential oils, resins and gums, sugars and starches, alkaloids and their derivatives, glucosides, proteids and nitrogenous animal substances, ferments and enzymes, phenols and miscellaneous substances. Some compounds in all organic classes showed marked beneficial action, but most of them were without any such effect. All the effective addition agents contain the hydroxyl group, but this relationship is too general to be of any value. The addition substances which are of value, arranged in the order of their beneficial action, are clove oil or eugenol, peptone, phloridzin, and gum guaiac. Clove oil is recommended for use in lead perchlorate plating and refining baths; about $\frac{1}{4}$ lb. is required per ton of lead. Phloridzin is, perhaps, a slightly more satisfactory addition substance, but its cost is prohibitive. In an appendix a method is given for the convenient preparation of perchloric acid.

T. S. P.

1234. *Hundred-volume Index to the "Chemical News," 1860-1909.* (712 pp., London, 1918.)—A combined subject and authors' index, alphabetically arranged, pertaining not only to the original communications published therein, but also to the reviews of books and the abstracts from other sources.

L. H. W.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1913.

GENERAL PHYSICS.

1235. *Spurge's Manometer.* (Engineer, 115. pp. 585-586, May 16, 1913.)—The article commences with a brief review of Torricelli's mercury manometer which still serves as a standard. The use of this for the accurate measurement of high pressure is critically examined, reference being made to instruments at the Eiffel Tower in Paris, at Manchester, St. Etienne, and in a well at Butte aux Caille, the length of the tube in the latter case being 1600 ft. and capable of measuring pressures of 9000 lbs. per sq. in. Disadvantages of such long tubes are pointed out. The dead-weight instrument, a more convenient form of manometer, is then described, but here again there is disadvantage when pressure variations have to be followed and noted, not to mention portability. Tait's method of checking the *Challenger* results is then described in detail, this forming the basis of Spurge's new type of manometer. Here advantage is taken of the elastic strain set up in a hollow cylinder or shell. A minute description of the instrument then follows, accompanied by diagrams. A table of corrections, supplied by the National Physical Laboratory, is added, whereby comparison is made with their dead-weight instrument. A mathematical discussion of these results then follows. The instrument has proved very serviceable when required to determine hydraulic pressure with precision. H. H. HO.

1236. *New Micromanometer.* J. D. Fry. (Phil. Mag. 25. pp. 494-501, April, 1913.)—The principle of the instrument is very simple, the difference of pressure to be measured being applied to the two sides of a stretched circular membrane so arranged that the centre of the membrane by its displacement twists a mirror which is suspended in a special manner, the pressure-difference being finally indicated by the deflection of a spot of light on a scale. With certain slight modifications, a manometer working on this principle may be adapted to the measurement of small differences of pressure at any absolute pressure. The present instrument has been designed for use at atmospheric pressure, and the author claims that in its most delicate form the new manometer possesses a sensitiveness at least ten times that of any micromanometer previously described. Since the displacement of a stretched membrane is dependent on its tension and stiffness, in order that it may be

proportional to the pressures applied it is important that of the two factors the tension should predominate, and to achieve this it is necessary to use a very thin membrane and to arrange that the tension to which it is subjected is considerable. If stiffness be neglected, the tension will remain constant when the displacement is small, the latter then being $pr^2/2T$, where p is the pressure-difference between the two sides, r the radius of the membrane, and T the tension in the membrane. The selection of the membrane depends on the order of magnitude of the pressure-differences required to be measured, and the following substances were tried: Thin sheet-rubber (which, although of extreme sensitiveness, cannot be put under sufficient tension to eliminate entirely a drift of zero), goldbeater's skin, cyclostyle paper, thin copper, and Badische coated with thin petrol-resin varnish to render it air-impervious. The latter proved the most suitable for indicating the smallest pressures. The construction of the manometer is then described in detail. All connections should be made with tubes of reasonably large diam., since with small-bore tubes effects due to viscosity become troublesome, and the manometer takes a considerable time to attain its final reading. The instrument must be calibrated, since the constant cannot be found *a priori*, and a special method is described, calibration curves being given under different conditions of sensitiveness. A table is added giving references to various recognised types of sensitive manometer, thereby serving as a rough comparison in relative sensitiveness. H. H. Ho.

1237. *Orthophotography*. J. M. Lahy. (Comptes Rendus, 156. pp. 1814-1817, April 28, 1918.)—Describes, with the aid of numerous diagrams, an apparatus designed to effect the correction (or rectification) of curves deformed by the circular movements of the style used for tracing the curves. A. W.

1238. *Work of the Reichsanstalt in 1912*. (Zeitschr. Instrumentenk. 88. pp. 84-98, March; 111-180, April, and pp. 152-172, May, 1918.)

1239. *Elastic Constants of Quartz Glass*. F. Stumpf. (Ann. d. Physik, 40. 5. pp. 879-886, April 29, 1918.)—The bending and torsion constants E and T were determined for four rods of amorphous quartz of rectangular section, using Voigt's apparatus. The mean values obtained are—

$$E = 7128 \text{ kg./mm.}^2, T = 8145 \text{ kg./mm.}^2.$$

Hence Poisson's ratio $\mu = 0.188$. These values of E and T are slightly higher than most of the values previously found by other experimenters. A discussion of the results by W. Voigt shows that they do not support the theory of the quasi-isotropy of quartz glass. A. W.

1240. *Elasticity of Thin Shells*. E. Meissner. (Phys. Zeitschr. 14. pp. 848-849, April 15, 1918.)—The theory of the elasticity of thin shells curved according to a surface of rotation and loaded with axial symmetry requires the integration of a differential equation of the fourth order, which is complicated even in simple cases. The author shows that a reduction to a differential equation of the second order takes place when the curvature of the meridian of the surface is constant, i.e. in the case of spheres, cones, and rings. The methods of integrating these equations are developed, thus enabling us to calculate the strength of such shells. The theory of a spherical vault is completely given. E. E. F.

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1241. *Collapse of Tubes by External Pressure.* R. V. Southwell. (Phil. Mag. 26. pp. 687-698, May, 1918.)—The author commences by referring to Basset's work in 1892, where a very clear exposition is given of the difficulties encountered in attempting to construct a theory of flue collapse. The conclusions arrived at show that Bryan's formula for the collapsing pressure of an infinitely long flue is probably correct as a first approximation, when the inner surface of the tube is free from applied pressures. Basset's work, however, is vitiated by the employment of a faulty expression for the strain energy of bending, and while the formula may be obtained by other methods, these also must be based upon inexact assumptions. The author claims to have investigated the problem by an exact method not involving the theory of thin shells. The results obtained show that Bryan's formula is correct as a first approximation, even when both surfaces of the tube are subjected to pressure, the difference of the pressures being the sole criterion of collapse. The conclusion reopens the examination of the theory of thin shells, since it appears more capable than hitherto supposed of providing a satisfactory formula for flue collapse, and the author indicates alterations in method which in his opinion evade Basset's difficulties. An extension of Bryan's formula then suggests estimates for the influence of "collapse rings" upon the strength of flues. Basset's notation being retained, the boiler-flue problem is thus stated: "Let the flue be regarded as indefinitely long and cylindrical; let $a + h$ and $a - h$ be the external and internal radii of its surfaces, π_1 and π_2 the respective outer and inner pressures. Then the condition of stability requires that a certain relation should exist between these four quantities, viz.: $F(a, h, \pi_1, \pi_2) > 0$." Basset suggested two methods for attacking the problem, viz. first the assumption of a slight deformation of the flue, when the condition of stability requires that the period of the small oscillations should be a real quantity; and second, that the potential energy in the deformed state being found, it should be a minimum for the equilibrium position. The value of the function F will be determined by either of these methods. The author proposes a third method, whereby the conditions which must obtain if a circular tube is in neutral equilibrium under the action of external pressure are investigated. Having found a value of the pressure for which the equilibrium is neutral, then by changing the equation into an inequality the stability condition is expressed. No alteration of Basset's methods is therefore involved, except the substitution of equations of equilibrium for his equations of small motion. Two configurations are then distinguished, viz. (1) the equilibrium position in which the tube remains circular and merely suffers contraction; (2) a configuration of infinitesimal displacement from this. The various expressions including Bryan's result are then deduced. The accepted formulæ for changes of curvature in terms of the corresponding changes in the stress couples need not be restricted to the case of shells where surfaces are free from stress, provided only that the changes under consideration are not accompanied by any change in the magnitude of the applied surface-tractions, which requirement is satisfied in the boiler-flue problem. From energy considerations Basset is right in saying that a complete expression for the potential energy will contain terms depending on π_1 and π_2 , although he has not shown that these pressures, when their intensity remains constant, influence to any sensible extent the increase of energy involved in a slight displacement from the equilibrium configuration. The author, from his results, obtained independently of the theory of thin shells, inclines to the view that they will not. The methods are then applied to obtain an estimate of the effect of "collapse rings," which

tend to prevent distortion of the tube at its ends, and the consequent strengthening effect is investigated by consideration of displacement types in which the departure of the cross-sections from circularity varies in the axial direction. A curve drawn connecting pressure and length is found to be discontinuous, thus throwing interesting light upon Fairbairn's formula, which makes the collapsing pressure inversely proportional to the length of the tube, thereby showing that comparatively short tubes must have been considered, since the possibility of discontinuities is neglected. H. H. Ho.

1242. Friction and Isochronism of the Double Spiral. J. Andrade. (Comptes Rendus, 156. pp. 1218-1219, April 21, 1918.)—In a previous communication [see Abstract No. 1455 (1911)] the author has dealt with the law relating to the oscillations of a balance regulated by two spirals, each adjusted by Le Roy's method. Following this came an experimental study of the most favourable modes of grouping two spirals for reducing lateral friction. In the present note a valuable property of a double spiral having coincident loops is discussed. The pressure supported by the common loop is purely radial, but the resulting friction does not disturb isochronism. The advantages from the use of a double spiral, or of a couple made up of two double spirals are briefly described, as also its application to the problem of regulating a marine chronometer. H. H. Ho.

1243. Properties and Structure of Ice. R. S. Tarr and J. L. Rich. (Zeitschr. f. Gletscherkunde, 6. p. 225. Nature, 91. p. 807, May 22, 1918. Abstract.)—Experiments made with various kinds of ice (pond, granular, snow glacier) support the views of Mügge and McConnell against Tyndall and Moseley, who did not sufficiently allow for the time element. Ice welds readily at 0°; when a block has been cut by a wire, optical continuity is re-established after regelation; the welding at temperatures below the freezing-point leads to a structure resembling that of crushed marble. Plastic deformation does not appear to set in before a certain strain has been reached; the deformation and optical properties are influenced by the direction of the crystal; granular ice is also deformed. A cake of pond ice, 80 cm. thick, consisted of 10 cm. of fine granular ice (top), 15 cm. of coarse prismatic crystals at right angles to the water surface, and 5 cm. of granular ice with crystals of diverse orientation. H. B.

1244. Shapes of Drops and Bubbles. A. Ferguson. (Phil. Mag. 25. pp. 507-520, April, 1918.)—(1) In this paper methods are described by means of which approximations to the outlines of large bubbles and drops may readily be made. These differ slightly in their correcting terms from those obtained by other methods. (2) A mechanical or planimetric method of integration is also described which is applicable to drops and bubbles of all sizes. (3) The more frequent use of photography in such measurements is advocated, and (4) some experimental illustrations of the photographic method are given and five photographs reproduced. E. H. B.

1245. External Friction of Gases. W. Gaede. (Ann. d. Physik, 41. 2. pp. 289-336, June 8, 1918.)—(1) The flow of hydrogen through a narrow slit between two glass plates at pressures from 1 atmo. to 0.02 mm. was investigated: deviations from the theory of Knudsen are observed. (2) By investigations on the flow of gas mixtures it was made manifest that the friction between the gas and the wall of the chamber is influenced by the

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formation of a *gas-skin*. The greater the total pressure of the gas mixture the more clearly marked is the gas-skin and the more does the external friction exceed the value to be expected on Knudsen's theory. (8) The flow of hydrogen and nitrogen through a capillary was investigated at low pressures down to 0.0002 mm. At pressures under 0.001 mm. the theory of Knudsen was satisfied, but not at higher pressures. Various other points were also dealt with. [See Abstracts Nos. 871 (1909) and 501 (1910).]

E. H. B.

1246. Internal Friction of Rarefied Gases. A. Timiriazeff. (Ann. d. Physik, 40. 5. pp. 971-991, April 29, 1913.)—Discusses the subject of internal friction in gases at low pressure, also the connection between "slipping" and the discontinuity of temperature at the boundary between metal and gas. [See Abstract No. 882 (1912).] A method of stationary deflections was used for a new investigation of the internal friction in the pressure interval 760 to 0.001 mm. of Hg. A theoretical investigation, based on the Maxwell-Boltzmann gas theory, is given, and the experimental results for air and CO₂ are in good agreement with the theoretical results.

A. W.

1247. Exceptional Collisions of Gas Molecules. P. Langevin and J. J. Rey. (Le Radium, 10. pp. 142-145, April, 1913.)—The distribution of velocities being assumed to follow the Maxwell law, it is here shown that the number of collisions per sec. per unit volume which present a normal velocity component exceeding v is the fraction $e^{-hmv^2/2}$ of the total number of collisions. It is then calculated that, for air at ordinary temperature and pressure, and for collisions sufficient to dissociate the molecules,

$$h = 12.5 \times 10^{13} \text{ and } \frac{1}{2}mv^2 = 8.7 \times 10^{-13} \text{ erg.}$$

This number of ergs is of the order required for a corpuscle to ionise a molecule.

E. H. B.

1248. Coefficient of Diffusion for Gases according to O. E. Meyer. J. P. Kuennen. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1152-1156, May 30, 1913.)—The author discusses the various methods of deriving an expression for the coefficient of diffusion from the kinetic theory, on the assumption that the molecules behave like elastic spheres, with the object of finding why that of O. E. Meyer leads to a result differing largely from the others and from observation, although the fundamental assumptions are essentially the same. The deduction of Meyer's formula is given, and the remark made that according to it the coefficient of diffusion varies strongly with the composition of the mixture. The experimental evidence, however, is in favour of a coefficient which varies only to a very small extent, and therefore puts Meyer's formula out of the question. The coefficient of diffusion according to Stefan is independent of the composition of the mixture, and agrees approximately with experiment. The latter was proved by Langevin to follow from Maxwell's second theory when applied to elastic molecules, and the only simplifying assumption which Langevin had to make for carrying out the required integration was, that in ordinary slow diffusion Maxwell's law of distribution may be taken as fulfilled. The want of rigour which this implies may perhaps account for the small difference between the formula and observation. Several physicists have tried to account for the great difference between Meyer's result and the others. Gross criticised the superposition of the gas current on the diffusion current, and proposed

leaving out the former while modifying the latter. This, however, is certainly illegitimate, as the gas is presupposed to be at rest or the plane through which the diffusion streams is calculated to move with the gas. Langevin pointed out that Meyer took no account of dynamical action between the two kinds of molecules, but he, like Boltzmann, does not attempt the solution. Jeans has shown the possibility of removing the greater part of the contradiction by making use of the notion of persistence of molecular velocity, a notion which plays an important part in the theory of the Brownian movement. This quantity depends on the principle that when a molecule collides with other molecules, it will after a collision have retained on the average a component of velocity in the original direction. Jeans has shown that the usual calculations in the kinetic theory of the various transport-phenomena, of which diffusion is an example, have to be corrected for this persistence, but his modification of Meyer's formula does not effect any improvement, as the diffusion coefficient has merely been multiplied by a constant factor, and the anomalous dependence on the number of molecules remains. The author points out that Jeans has overlooked the important fact that the persistence obtains a different value when a mixture of two kinds of molecules of different mass is dealt with. By taking account of the latter point, the author finds the modified formula to agree practically with Stefan's expression. Since Jeans's method of calculating the persistence is not rigorous, it might perhaps be found possible by applying more rigorous methods to reduce the remaining difference between Meyer's corrected formula and the other one. The author points out that the method indicated in this paper can immediately be used to deduce rational formulæ for the viscosity and the conduction of heat for gas mixtures. H. H. Ho.

1249. *Brownian Movements of Particles not Spherical.* K. Przibram. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2339-2350, Dec., 1912.)—As material the chains of dead *Bacillus subtilis* was used, the observations being made with a Siedentopf's cardioid condenser. The results are given in elaborate tables and graphically exhibited also. Some theoretical deductions the author was unable to confirm. [See Abstract No. 748 (1906).] E. H. B.

1250. *Inertia and Weight Masses in Relativity Mechanics.* G. Nordström. (Ann. d. Physik, 40. 5. pp. 856-878, April 29, 1918.)—A highly analytical treatment reaching the following conclusions:—The gravitational acceleration is less the greater the velocity is, but is independent of the direction of that velocity. Thus a horizontally-projected body falls slower than one starting vertically from rest. [See Abstracts Nos. 1086 (1911) and 29 (1912).] E. H. B.

1251. *Velocity Distribution of Air near Wire moving Lengthwise.* K. Przibram. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2338-2337, Dec., 1912.)—Describes, but without a diagram, the arrangements for observing microscopically the motions in question. A logarithmic graph gives straight lines. E. H. B.

1252. *Principle of Least Action and Relativity.* E. Henschke. (Ann. d. Physik, 40. 5. pp. 887-934, April 29, 1918. Author's Dissertation, Berlin.)—A highly analytical treatment of the subject, being a continuation of a previous article [see Abstracts Nos. 2277 (1905), 1990, 1991 (1906), and 1587 (1911)]. E. H. B.

1253. *A Long-range Weather Forecast for the East Monsoon in Java.* C. Braak. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1068-1069, May 30, 1918.)—The author has previously found that in the Indian Archipelago a connection is clearly perceptible between the barometric pressure and rainfall [see Abstract No. 856 (1918)]. In the present paper this connection is made use of for forecasting the rainfall in Java. A curve is reproduced showing the departures from normal of the air pressure in Port Darwin. This curve shows several series of well-marked 8-year waves separated by broken irregular periods, which latter are found to correspond to the maxima of the sun-spot curve. The connection is next considered between these regular pressure-waves and the West Java rainfall, and a set of laws which appear to govern the relationship between the two elements is drawn up. These laws are applied to the situation at the time of writing the paper, and it is concluded that most probably the East Monsoon in Java of 1918 will deviate in the wet, and that of 1914 probably in the dry, direction from the mean. J. S. Dr.

1254. *The Unusual Atmospheric Haziness during the latter part of 1912.* H. H. Kimball. (Washington Acad. Sci., Journ. 8. pp. 269-278, May 19, 1918.)—A large amount of data was collected from the United States, Canada, and the North Pacific, and from this the conclusion is reached (1) that the meteorological conditions were especially favourable to the formation of haze, and (2) that the origin of some of the haze was to be found in the smoke from forest fires in Canada and British Columbia and in smoke or dust from Katmai Volcano. The haze was not observed in Europe and Northern Africa until about a fortnight later than in the United States. J. S. Dr.

1255. *Exposure of Thermometers for the Determination of Air Temperature.* (Nature, 91, p. 361, June 5, 1918. Abstract of Report of Prussian Meteorolog. Inst., 1911.)—Thermometers exposed at a north window (formerly the usual method adopted in Germany) give readings in good agreement with those of an aspirated thermometer in the same neighbourhood. The true temperature in the shade on the north side of a building differs considerably from the temperature in an open field. At 2 p.m. in July the latter is 1°C . in excess, but the mean temperature for the day is not widely different in the two places. The afternoon readings in a Stevenson screen in North Germany tend to be slightly too high, 0.1 - 0.2° in winter, 0.2 - 0.4° in summer. The errors differ with different climates and with varying conditions of weather. J. S. Dr.

1256. *Effect of the Atmospheric Turbidity of 1912 on Solar Radiation Intensities and Skylight Polarisation.* H. H. Kimball. (Mount Weather Observatory, Bull. 5. Part 5. pp. 295-312, 1918.)—The general nature of the effects have already been discussed [see Abstract No. 162 (1918)]. The present paper is devoted to a more detailed study. The radiation intensities measured at Madison, Wis., during the second half of 1912 averaged only 86 per cent. of the intensities measured in the corresponding period of 1910 and 1911. At Lincoln, Nebr., the intensities in Nov., 1912, averaged only 82 per cent. of the corresponding intensities in Nov., 1911. The percentage of polarisation of skylight with the sun at zenith distance 60° was also below the normal in the second half of 1912. A large increase in polarisation near the zenith was found to occur just after sunset similar to that in 1908, after the eruption of Mount Pelée. It has been found, both on the present

and on previous occasions, that periods of decreased solar radiation intensity have been accompanied and followed by a marked increase in the solar distance of Babinet's neutral point at about the time of sunrise and sunset.

J. S. DI.

1257. *Earth's Rotation Demonstrated.* A. H. Compton. (Science, 87. pp. 808-808, May 23, 1918.)—The two methods generally known for demonstrating the earth's rotation are Foucault's pendulum and the gyroscope, but the former requires a great height and the latter is very expensive. The method here detailed involves the use of a circular tube filled with water and placed in a plane perpendicular to the earth's axis. Then in the upper part of the tube the water is moving to the east with respect to the lower part. If the tube is quickly rotated through 180° about its east and west diameter, this action is reversed and can be detected by the motion of globules of linseed oil and oil of cloves of the same mean density as the water and which is observed by a micrometer microscope.

E. H. B.

1258. *Elasticity of the Earth and the Earth's Crust.* T. Shida. (Coll. Sci. and Engin., Mem. Kyōtō, 4. 1. pp. 1-284, Nov., 1912.)—This monograph consists of six parts, and is largely of a tabular and graphic nature; no abstract is possible. The main divisions are: I. Horizontal pendulum observations of the change of plumb-line at Kamigamo. II. The atmospheric tide. III. [with M. Matsuyama] Hecker's observations of pendulums. IV. Paths and transit times of preliminary tremors of near earthquakes. V. Attempt to find the Chandler period of free nutation. VI. [with M. Matsuyama] Change of plumb-line referred to the axis of the earth as found from International Latitude Observations.

L. H. W.

1259. *Expedition for the Observation of the Aurora Borealis at Bossekop in the Spring of 1918.* C. Störmer. (Comptes Rendus, 156. pp. 1871-1872, June 16, 1918.)—In this expedition, undertaken to complete the results of a previous one in 1910, 450 pairs of simultaneous successful photographs were taken from Bossekop and Store Korones, 27 km. apart. Photographs were also obtained of the spectral lines of stars superimposed on those of the aurora. Two plates accompany the article, one showing a 4-sec. exposure cinematograph record of an aurora. A detailed memoir is to follow.

H. F. H.

1260. *On a Curious Aspect of the Third Satellite of Jupiter.* J. Guillaume. (Comptes Rendus, 156. pp. 1786-1787, June 9, 1918.)—On May 24, from Lyons Observatory, with a magnification of 865, Ganymede presented an oval shape, instead of its usual round disc; and a very white polar spot could be distinguished upon it, with a smaller grey zone below. A similar phenomenon, but less marked, had been observed before by the author in 1890 and 1898. The luminosity of each of the satellites I., II., and III. was sensibly the same, and normal.

H. F. H.

LIGHT.

1261. Thermal Microscope for Measurement of Optical Constants of Minerals at High Temperatures. F. E. Wright. (Washington Acad. Sci., Journ. 8. pp. 232-236, April 19, 1918.)—With this new microscope three optical constants—birefringence, extinction angle, optic axial angle—of a properly oriented crystal plate can be measured accurately at any temperature between 10° C. and 1200° C. Above 1200° C. the intensity of illumination from the furnace itself is so great that it tends to veil the optical phenomena produced by the polarised light-waves transmitted through the plate. The thermal microscope consists of two parts: (i) a petrographic microscope equipped with a suitable device for simultaneous rotation of the nicols, either by means of gear-wheels connected by a bar or by means of a direct connecting bar, the second method being the more accurate and satisfactory; (ii) an electrical resistance furnace which is enclosed within a water-jacket. Constructional details of the furnace are given; the temperature measurements are made by means of a thermo-element in contact with the mineral plate, which is held in position by Pt jaws. Particulars are given of the method of adjustment of the crystal plate and of the methods of determining the three constants above mentioned. A. W.

1262. Strioscope and Interferential Striograph. G. Sagnac. (Journ. de Physique, 8. Ser. 5. pp. 81-89, Feb., and pp. 292-305, April, 1918.)—Two prisms, whose dihedral obtuse angles are a little less than 120° , are placed with their larger faces together, but separated by a thin film of air. Parallel light incident on one of the smaller faces is partly reflected and partly transmitted by the air film between the two prisms, and the reflected and transmitted portions traverse in opposite directions an approximately rectangular path, being reflected from plane mirrors at the corners, and being finally reflected and transmitted respectively by the air film. In the striograph a photographic apparatus receives the beams twice reflected and twice transmitted respectively by the air film. In the strioscope an eyepiece replaces the photographic apparatus. A polariser is used to give light polarised either parallel or perpendicular to the plane containing the central ray, and the apparatus is adjusted so as to give, for a certain wave-length, equality of amplitude of the reflected and transmitted beams. Owing to the perfect transparency of the air film there is rigorous opposition of phase of the two beams, and so with monochromatic light the central fringe is enlarged indefinitely and the field of interference is uniformly dark. The appearance of the field is described when various objects are interposed; the hot air rising from the fingers of the hand gives rise to very bright bands, an action much too strong to give an idea of the sensibility of the method. Theory is given, and the method of adjustment described. An apparatus of small dimensions is obtained by replacing one of the triangular prisms by one whose section is a parallelogram, having thus a face parallel to the air film at which the light is totally reflected internally, and which thus replaces one of the plane mirrors of the larger apparatus. The other two mirrors are replaced by two faces of another triangular prism. An example of the use of the apparatus is given in a study of the action of a helix on a gaseous jet. A. W.

1263. Gelatine Colour-filters for Mercury Lamps. H. Schulz. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 286-289, April 80, 1918.)—Describes the results obtained by passing the light from a mercury lamp through a series of colour-filters. The filters isolate the lines $579 + 577 \mu\mu$, $546 \mu\mu$, $486 \mu\mu$, $407 + 405 \mu\mu$, and $865 \mu\mu$; they are prepared by C. P. Goerz. A. W.

1264. Elastic Deformation and Selective Absorption. P. Selényi. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 290-291, April 80, 1918.)—Gives an account of experiments made with the object of ascertaining whether pressure applied to a ruby, cut perpendicular to the optic axis, had any effect on the absorption spectrum. Pressures up to about 150 kg./mm.² were employed, but no positive result was obtained. The experiment was carried out at liquid-air temperature, at which H. du Bois has shown [Abstracts Nos. 1108 (1908) and 67 (1909)] that the absorption spectrum of ruby exhibits very fine lines. [See also Abstract No. 888 (1902).] A. W.

1265. Effect of Reflection from a moving Mirror on the Velocity of Light. A. A. Michelson. (Astrophys. Journ. 87. pp. 190-198, April, 1918.)—According to the undulatory theory of light the velocity of light is independent of the velocity of the source, and of the velocity of a mirror at which it is reflected. According to the emission theory the resultant velocity from a moving source is increased by the component of the velocity of the source. But it appears that different forms of emission theory require different results on reflection from a moving mirror. If the light-corpuscles are reflected as projectiles from an elastic wall, then the velocity of light should be increased by twice the component of the velocity of the mirror [Abstract No. 56 (1918)]. The following arrangement was devised for the purpose of deciding the question experimentally. Light from a source S falls at 45° incidence on a lightly silvered mirror A. The reflected pencil goes to a mirror D, thence to a concave mirror E, to a second mirror C (revolving about the same axis O as the mirror D), whence it proceeds to a plane mirror B, and is reflected back to A. The pencil transmitted by A follows the same path in the opposite direction, returning via DA to the starting-point, where it meets the first pencil, producing interference fringes which are observed by means of a telescope with micrometer eyepiece. Theory shows that the displacement Δ of the fringes seen in the telescope is given by $\Delta = 4D(2 - r)v/\lambda V$, where D is the distance OE, V is the velocity of light, v the component of the velocity of the mirror in the direction of the reflected pencil, and $r = 2$ according to the elastic impact theory, $r = 1$ if the mirror surface acts as a new source, while $r = 0$ on the undulatory theory. The experiment was tried under the following conditions: The revolving mirrors were mounted on the shaft of an electric motor, the speed of which could be varied from zero to 1800 r.p.m. The distance l between the centres of the mirrors was 26.5 cm., and the distance OE was 608 cm. Light of mean wave-length 0.6μ was used. The displacement formula for $r = 0$ becomes $\Delta = 8\pi N/D/60\lambda V$, where N is the number of turns per min., and on substitution of the above values, putting $N = 1000$, Δ was found to be 8.76. The mean value of the observed displacement was 8.81. Hence it appears that within the limit of error of experiment (say 2 %) the velocity of a moving mirror is without influence on the velocity of light reflected from its surface. Assuming that the effect is actually nil, this interference method may be used to measure the velocity of light with an order of accuracy equal to that of the improved Foucault method, or of the "combination" method [Abstract No. 1508 (1902)]. Any one of these three

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methods is capable of furnishing results of the order of accuracy of 1 in 10^6 ; and differential measurements (*e.g.* with the light of the two limbs of the sun) can be obtained with a still higher degree of precision; thus the effect of a moving source on the velocity of light could be determined. A. W.

1266. *Refractive Indices of Gases under High Pressures. II. Dispersion of Air and of Carbon Dioxide.* L. H. Siertsema. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 925-981, April 24, 1918.)—The measurements on these two gases were made exactly as with hydrogen [see Abstract No. 801 (1912)]. The dispersion constants for air were found to be the same for all pressures up to about 100 atmos., their values being as follows:—

$\lambda = 0.644$	0.546	0.509	0.472	0.436	0.405
0.9945	1	1.0030	1.0087	1.0114	1.0166

These results, which are tabulated together with those of other observers, can be expressed by the formula—

$$c = (n - 1)/(n_b - 1) = 0.98086(1 + 0.0056376/\lambda^2 + 0.00005401/\lambda^4).$$

With carbon dioxide the dispersion is independent of the pressure up to the saturation pressure. The results obtained are as follows:—

$\lambda = 0.644$	0.546	0.509	0.472	0.430	0.405
0.9987	1	1.0084	1.0074	1.0126	1.0181

The interpolation formula expressing these values is—

$$c = (n - 1)/(n_b - 1) = 0.97781(1 + 0.0067868/\lambda^2 - 0.00000614/\lambda^4),$$

which is in good agreement with the theoretical dispersion formula; the wave-length *in vacuo* is calculated to be 0.07982 μ . T. H. P.

1267. *Electric Double Refraction.* C. Gutton. (Comptes Rendus, 156. pp. 1870-1878, May 5, 1918.)—In a previous paper [Abstract No. 1181 (1918)] the author has shown that the variations of electric double refraction of liquids do not follow instantaneously the variations of the electric field. The present paper describes the method of determining the time required for the establishment of electric double refraction. The arrangement of apparatus was the same as for the earlier experiments. By charging the condensers with Hertzian waves of lower and lower frequencies, a point is reached at which the compensation, already established for static charges, holds good for the oscillatory charges. The variations of intensity of the electric field are then slow enough to allow the double refraction of the two liquids to reach their normal values. The time of charging of the condensers being equal to the time during which the Hertzian waves travel $\frac{1}{2}$ wave-length, the measurement of this wave-length serves to determine the time required to establish double refraction in the liquid whose double refraction follows less quickly the variations of intensity of the electric field. The electric oscillations were produced by oscillators of the Lecher type, the smallest being completely immersed in vaseline, and a Tesla transformer was used. The Hertzian waves were led to the condensers by wires 16 m. long, in which the position of the internodes of the stationary waves obtained by reflection from the ends could be observed. Using naphthalene bromide and carbon disulphide it was found that with oscillations of half wave-length 850 cm., there was compensation for oscillatory as well as for static charges. For half wave-length 95 cm. the distance apart of the plates of one

of the condensers had to be diminished by 8·5 %, this diminution being smaller and smaller as the half wave-length was increased to 850 cm. From this it is deduced that the time required for the establishment of electric double refraction in carbon disulphide is $1·4 \times 10^{-6}$ sec. Other experiments give for toluene the value $1·7 \times 10^{-6}$ sec., and for naphthalene bromide $0·6 \times 10^{-6}$ sec. These results are of the order of magnitude required by the theory developed by Langevin, according to which the phenomenon is the result of molecular orientation. A. W.

1268. Measurement of Wave-length Differences. P. P. Koch. (Ann. d. Physik, 41. 1. pp. 115–128, May 22, 1913.)—Gives first a discussion of Priest's method of measurement [Abstract No. 884 (1910)], which differs from the method previously adopted with the Fabry and Perot interferometer [Abstract No. 1969 (1908)]. A photometric method is then described, in which use is made of the effect of a weak magnetic field on the red Cd line $\lambda 6489$. [See also Abstracts Nos. 1192 (1912) and 410 (1913).] A. W.

1269. Optical Constants of Sodium and Potassium. R. W. and R. C. Duncan. (Phys. Rev. 1. Ser. 2. pp. 294–308, April, 1918.)—It was found possible to obtain, and preserve indefinitely, bright surfaces of both Na and K by melting the metal in an evacuated chamber of special construction, and allowing the metal to solidify in a small capsule with plane glass ends, the opening being finally closed with paraffin. The experiments described show that metallic Na has the lowest index of refraction and the highest reflecting power of any metal known. This is in agreement with Drude's observations. The value of the refractive index for Na light is very near the upper limit (0·054) set by Drude. The values of the optical constants for (1) Na and (2) K were found to be—

	λ .	n .	κ .	Φ .	Ψ .	R.
(1)	6650	0·051	55·0	72° 11'	44° 29'	97·7
	5893	0·044	55·0	68° 51'	44° 29'	97·1
	5460	0·052	42·6	68° 48'	44° 20'	96·5
	4720	0·057	38·8	66° 29'	44° 9'	95·2
	4350	0·058	31·7	66° 0'	44° 6'	94·8
(2)	6650	0·066	26·8	65° 27'	43° 56'	98·8
	5893	0·068	22·1	62° 58'	43° 42'	92·0
	4720	0·070	14·8	57° 9'	43° 0'	86·9

The curve connecting n and λ for Na shows a distinct minimum near the D-line. Next to Na, K has the lowest index of any metal. Its reflecting power, however, is slightly less than that of either Ag or Na. A. W.

1270. Dispersion of Metals. L. P. Wheeler. (Amer. Journ. Sci. 85. pp. 491–508, May, 1918. Phil. Mag. 25. pp. 661–679, May, 1918.)—From an examination of the available data on the dispersion of Ag, Cu, Au, Ni, and Co, it is concluded that the inaccuracies in the experimentally determined values of the optical constants of these metals are too great to allow of much dependence to be placed on them except for *relative* values. These uncertainties limit seriously the information to be derived from the measurements, and suggest the desirability of obtaining data on the dispersion of Hg, for

which metal the causes of the inaccuracies can be eliminated. From a comparison of the data with the dispersion formulæ yielded by the electron theory, it appears—(i) That the number of free electrons is not a constant, but increases with the frequency of the currents set up by the incident radiation; slowly and uniformly in the infra-red, and more rapidly in the regions where the metals are more transparent. The explanation of this phenomenon is so involved with that of the mechanism of metallic absorption in general, that a wholly satisfactory elucidation of it seems to be impossible at the present time. (ii) That the dispersion of the so-called dielectric constant for these metals can be determined. It is seen to consist of two parts, of which that which depends on the presence of free electrons is more important than the other or pure dielectric term, especially at the shorter wave-lengths. It also appears that the form of the dispersion curves found is not inconsistent with that demanded by theory, although the inaccuracies of the data do not permit a satisfactory investigation of this point. [See also Abstracts Nos. 1889 (1908) and 859 (1912).] A. W.

1271. *Trend of Geometrical Optics.* S. P. Thompson. (Optical Convention, Proc. 2. pp. 297–804, 1912. Phys. Soc., Proc. 24. pp. 859–867, Oct., 1912. Abstract.)—With the exception of the formation of images upon the retina of the eye, and the system proposed by Biot and Bosscha, and adopted by Cornu and Sissingh, the method of Gauss for the treatment of lens systems by means of points and planes, as amplified by Listing and Toepler, and further developed by Blakesley, is now universally accepted, and the author points out its applicability to the solution of many lens problems. The need for improvement in defining the different uses of the terms *magnification*, *positive* and *negative*, is suggested, as also for suitable English equivalents for the German terms *Scheitel*, *Schnittweite*, *Durchbiegung*, *Durchrechnung*, *Abbildung*, *Porrhallaxie*. W. H. St.

1272. *Polarisation of Light by Internal Diffusion.* G. Dimmer. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1517–1588, Oct., 1912.)—This is the fifth of a series of communications on the above subject; it is partly theoretical and partly experimental, the results being summarised in seven tables and eleven diagrams showing a number of graphs co-ordinating percentages of light polarised and angles. [See Abstract No. 1025 (1912).] E. H. B.

1273. *Demonstration of Spectrum Colours.* M. Siegbahn. (Phys. Zeitschr. 14. p. 412, May 1, 1918.)—Photographs of spark spectra may be shown in their original colours by using the apparatus with which they were taken, or some apparatus giving the same dispersion, for projection. A direct-vision spectroscopie is most convenient. The slit is placed in contact with the lantern condenser. The continuous spectrum of the arc then illuminates the diapositive in the proper colours, and the image of the diapositive, thus coloured, is projected on a screen by another lens. E. E. F.

1274. *Arc and Spark Spectra of Calcium.* O. Holtz. (Zeitschr. wiss. Phot. 12. pp. 101–121, May, 1918.)—Describes measurements of the wave-lengths of the lines in the arc and spark spectra of Ca in international units. The results are tabulated and compared with previous measurements. The wave-lengths are given of the lines in three groups of chloride bands. A. W.

1275. Effect of Self-induction on the Spark Spectra of certain Non-metallic Elements. G. V. Morrow. (Roy. Dublin Soc., Proc. 18. 89. pp. 607-620, May, 1918.)—The spectra of the following substances were examined, using both gold and carbon electrodes, with and without self-induction: N, O, H, Cl, Br, I, S, P, BCl₃, SiCl₄, SO₂, H₂S, CO₂, CO, and HCl. It was found that sparking between electrodes in an atmosphere of any kind gives the principal lines of the line spectra of the elements present in the atmosphere, and as a rule with greatest intensity when self-induction is not introduced. In the case of hydrogen, the only electro-positive gas examined, the effect of self-induction is to intensify and sharpen the H lines, and to remove, or nearly so, the lines of gold or carbon; whereas, in the case of electro-negative gases such as O and N, the effect of self-induction is to remove, or almost entirely remove, the spectra of these gases, the gold and carbon alone showing. With elements such as Cl, Br, and I, the effects of self-induction are not so pronounced. In the case of carbon the effects of self-induction are pronounced and very remarkable. First, with self-induction, the three bands attributed to cyanogen are seen clearly defined in almost any atmosphere except H, but without self-induction only the one band at $\lambda 8888.6$ is seen, and it also is seen in any atmosphere except H. Adopting the theory of Schuster and Hemsalech, that the current is conveyed across the gap at first by the air when there is no self-induction, it is concluded that under these conditions the temperature is too high for cyanogen to be formed by the carbon electrodes and any trace of N present. If this be so, the band which remains when self-induction is absent is probably due to carbon and not to cyanogen. [See also Abstract No. 858 (1912).] A. W.

1276. Absorption of Light by Water changed by Presence of Strongly Hydrated Salts. J. S. Guy, E. J. Shaeffer and H. C. Jones. (Amer. Chem. Journ. 49. pp. 265-286, April, 1918. Phys. Zeitschr. 14. pp. 278-288, April 1, 1918. Chem. News, 108. pp. 26-29, July 18, and pp. 87-41, July 25, 1918.)—By means of the radiomicrometer it has been shown that water containing strongly hydrated salts such as the chlorides of magnesium, calcium, and aluminium is more transparent than pure water, and that the band is shifted towards the region of longer wave-lengths. The suggestion is made that the water combined with the salt has a smaller absorptive power than free uncombined water. T. M. L.

1277. Absorption of Light by Inorganic Salts. VII. Aqueous Solutions of Iron-Salts. J. S. Anderson. (Roy. Soc. Edinburgh, Proc. 83. pp. 85-43, 1912-1918.)—The absorption-bands in the visible spectrum shown by solutions of ferric chloride in alcohol do not occur in the aqueous solutions, but the infra-red band at about 1μ is very marked in the case of the chloride, nitrate, and sulphate, increasing in height and moving towards the visible region on dilution; in the case of the bromide the band shifts in the same direction, but the height increases on dilution. The general absorption in the visible region increases on dilution in the case of ferric nitrate and sulphate, decreases in the case of the bromide, and first decreases and then increases in the case of the chloride. This last increase of absorption in dilute solutions is more marked after keeping, and is perhaps due to the formation by hydrolysis of colloidal ferric hydroxide. T. M. L.

1278. Absorption of Light by Inorganic Salts. VIII. Alcoholic Solutions of Copper, Cobalt, and Nickel Salts in the Ultra-violet. A. R. Brown. VOL. XVI.—A.—1918.

(Roy. Soc. Edinburgh, Proc. 88. pp. 44-48, 1912-1918.)—The absorption of light by copper chloride and copper bromide in the extreme ultra-violet is much increased by changing from aqueous to alcoholic solutions. The changes observed on increasing the concentration of nickel chloride in aqueous solutions are carried still further by dissolving in alcohol: they are therefore probably caused by dehydration. T. M. L.

1279. *Theory of Band Spectra.* J. Stark. (Phys. Zeitschr. 14. pp. 454-456, May 15, 1918.)—A reply to the criticisms of Burger and Koenigsberger [Abstract No. 597 (1918)]. The emission of band spectra is not necessarily conditioned by a total splitting-off of valency electrons. The latter is only a special case. The absence of the Zeeman-effect in band spectra is no objection to their electronic origin. It only means that the force maintaining the electron in its orbit is not directly proportional to the distance from the attracting centre. It cannot, in fact, be that, or the electron could not be split off. Valency electrons may absorb light without ionisation taking place. They may hand on the energy received to other constituents of the atom. E. E. F.

1280. *Vacuum-tube Discharge in a Magnetic Field.* N. A. Kent and R. M. Frye. (Astrophys. Journ. 87. pp. 188-189, April, 1918.)—Describes an investigation of the changes which take place in the spectrum of the vacuum-tube discharge when placed in a magnetic field. A brief *résumé* of previous work is given and photographs are reproduced. A Hilger single-prism spectrograph was employed, and fields up to 25,000 gauss were obtained with a Weiss electromagnet. The vacuum-tube discharge is certainly a complex phenomenon, owing to the large number of variables to be considered—potential, current, resistance, temperature, pressure, frequency, and composition of the gaseous mixture contained in the tube. The magnetic field has a decided effect. Ordinarily, in a given tube, the size of the capillary is constant, but the magnetic field, by forcing the ions to use only a small part of the capillary, virtually changes the effective cross-section. This increases the resistance of the tube, and diminishes the value of the current flowing. Secondly, the mechanical bombardment of the walls of the tube by the ions liberates material from the glass and adds to the complexity of the gaseous mass under investigation; and, thirdly, these same collisions are probably one of the factors which result in the decomposition of the bombarding ions into simpler forms. In general, then, these three factors result in (a) the production of spectra either of substances already present in the tube as impurities or of dissociation products either (b) of the original gas or (c) of the glass. Examples of these are seen in (a) the enhancement of the hydrogen lines in an argon tube (which contained hydrogen as an impurity) when the tube was subject to the proper conditions; (b) the change from the band to the line spectrum of nitrogen or the production of the oxygen spectrum in a carbon-monoxide tube; and (c) the production of not only the sodium but the oxygen spectrum from the glass. Some peculiar phenomena were observed with a nitrogen tube. A. W.

1281. "*The Red Lithium Line.*" P. Zeeman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1180-1181, May 80, 1918. Phys. Zeitschr. 14. pp. 405-406, May 1, 1918.)—Magnetic fields only resolve spectrum lines belonging to pair series or to threefold series into complicated types, *i.e.* not into triplets. The cause of the complicated resolution is intimately
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connected with the presence in the spectrum of natural groups of two or three lines (series-doublet or series-triplet). It has nothing to do with the distribution of lines in series, for there exist connected series of lines, which are resolved into triplets by magnetic fields [see Abstract No. 617 (1906)]. Lines belonging to a very close series-triplet or series-doublet have recently [see Abstract No. 419 (1918)] been found by Paschen and Back to influence each other in a very peculiar manner. When a sufficiently strong magnetic field is applied, a normal triplet is seen instead of an expected superposition of the types of separation of the compounds. Lithium was one of the metals investigated by Paschen and Back, and on analogy with the other alkali metals it might be expected that the Li lines are very close pairs, although opinions have been expressed that the laws for the other alkali metals do not apply to Li. The author investigates the problem of finding whether the Li lines are really very narrow pairs or not by means of a method previously described. Inside the glass tube a small iron or copper vessel is placed to prevent the action of heated lithium on the glass. The observations were made in the second-order spectrum of a large Rowland grating. The red of the second order is superposed on the blue of the third order, so that the line 6708 is seen in the absorption spectrum as a blue line. With small vapour density the line resolved into two components, thus establishing the expected analogy with the other alkali metals. That component of the double line having the smaller wave-length appeared the most intense. The distance between the components was much smaller than that calculated from the empirical rule for elements of the same family.

H. H. Ho.

1282. *Zeeman-effect.* F. Paschen and E. Back. (Ann. d. Physik, 40. 5. pp. 960-970, April 29, 1918.)—A continuation of previous work [Abstract No. 419 (1918)]. The oxygen triplet $\lambda 8447$ was studied with still higher fields—ranging up to about 40,000 gauss. The research shows, from the marked definition of the parallel oscillating mean component of the resulting triplet, and the exact normal displacement of the mean perpendicular oscillating side components, such a close approximation to the normal Zeeman triplet that it can be concluded that the magnetic conditions employed yield the exact normal triplet; thus the author's theory is confirmed. The hydrogen lines H_α and H_β were also investigated for fields between 14,000 and 82,000 gauss. The general appearance of the Zeeman triplets of these lines was about the same as in weaker fields. The width of the side-lines was found to be the same as that of the polarised or unpolarised mean component. The diminution of the specific displacement $Z(= \Delta\lambda/\lambda^2 H)$ with increasing fields does not seem to agree with the discussion of Voigt [see Abstract No. 806 (1913)]. The equal breadth of the side and mean components of the triplets are not compatible with the first part of Voigt's discussion. On the other hand, it should be noted that the incomplete polarisation of the mean component can be explained by the theory. Also the independent development of the parallel and perpendicular oscillating components, of which the oxygen triplet gives a further example, is in agreement with one of Voigt's suppositions.

A. W.

1283. *Aluminium Lines in Canal Rays.* J. Stark, R. Künzer, and G. Wendt. (Preuss. Akad. Wiss. Berlin, Ber. 14. pp. 480-441, 1918.)—It has previously been shown that certain series of He are associated with the He positive singly-charged atomions, and that others are associated with the positive doubly-charged atomions [Abstract No. 982 (1918)]. In the present

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paper it appears that Al exhibits similar properties, and gives evidence of the existence in front of the kathode of singly-, doubly-, and trebly-charged ions, with three corresponding velocity-intervals. With a kathode fall of potential of less than about 8000 volts, the singly- and doubly-charged Al-ions preponderate over those trebly-charged; with a kathode-fall of over 8000 volts the number of trebly-charged Al-ions is considerably greater than that of the singly- and doubly-charged ions. The singly-, doubly-, and trebly-charged ions are the carriers of different spectral lines. To the spectrum of the singly-charged ions belongs the doublet $\lambda 8961\cdot7$, $\lambda 8944\cdot2$; to that of the doubly-charged ions the line $\lambda 4668\cdot5$; to that of the trebly-charged ions the lines $\lambda 4529\cdot7$, $\lambda 4518\cdot0$ and $\lambda 4480\cdot0$. A. W.

1284. *Fluorescence Spectrum of Iodine Vapour*. J. C. McLennan. (Roy. Soc., Proc. Ser. A. 88. pp. 289–296, May 8, 1918.)—The three lines 5460·74, 5769·60, 5790·66 of the Hg arc used by Wood in his work on resonance spectra [Abstracts Nos. 42 (1912) and 801 (1913)] are among the strongest in the Hg arc spectrum. The object of the present research was to detect, if possible, resonance or fluorescence spectra excited by other Hg lines, especially the stronger lines in the ultra-violet region. The tube used consisted of two parts, the outer part being made of glass of the ordinary Cooper Hewitt design, and the second part consisting of a tube of clear fused quartz extending well inside the glass tube and sealed into it by wax joints. The glass tube was furnished with Hg terminals and carried the Hg arc. Iodine in crystals was inserted in the quartz tube, which was then highly exhausted and afterwards sealed off. Thus the iodine vapour in the tube was subjected to intense illumination by light of wave-lengths extending beyond $\lambda 7000$ and down to about $\lambda 1850$. Examination of the light issuing from the exposed end of the quartz tube showed in addition to the ordinary Hg lines a number of narrow bands extending from about $\lambda 4600$ to about $\lambda 2100$. Photographs reproduced show a set of seven well-marked bands between $\lambda 8841\cdot7$ and $\lambda 8181\cdot7$ and also sets approximately equally spaced on either side of the line $\lambda 4858\cdot8$. A limited series of bands in pairs is distinguishable between $\lambda 8181\cdot7$ and $\lambda 2898\cdot7$, and a number of single bands can be seen between $\lambda 2898\cdot7$ and $\lambda 2586\cdot7$. Below $\lambda 2586\cdot7$ the bands are spaced at intervals of approximately 20 \AA . and extend to the limit of the photograph. A wave-length table of the heads of over 80 bands is given, from $\lambda 4608$ to $\lambda 2129$. With no iodine in the tube no bands could be observed, as was also the case when a tube of ordinary combustion glass was substituted for the quartz tube. It seems probable, therefore, that the emission of the band spectrum is a true resonance effect stimulated by the light from one or more lines in the Hg arc spectrum (doubtless in the ultra-violet region) to which the combustion glass tubing is not transparent. Up to the present it has not been possible to pick out, with any certainty, the lines which give rise to the new resonance spectrum, but experiments with this end in view are in progress. Explanations are given of the non-appearance of the lines of the Wood resonance spectra on the photographs. The conditions are favourable for the absorption of the lines of the Wood spectra. A. W.

1285. *Magnetic Spectrum of β -rays from Radio-Actinium*. O. v. Baeyer, O. Hahn, and L. Meitner. (Phys. Zeitschr. 14. pp. 821–828, April 15, 1918.)—A preparation of radio-actinium was obtained in great purity by repeated precipitation with ammonium thiosulphate. It was finally deposited electrolytically on silver wires 0·15 mm. thick from an HCl solution. Such a

preparation corresponded radio-actively to 0.05 mgm. RaBr. The magnetic spectrum was obtained as before [see Abstracts Nos. 1968 (1908), 245 (1912)], the exposure being 9 hours. In that time not more than 8.5 per cent. AcX and of its disintegration products were formed. The photograph (reproduced) shows 7 distinct groups of β -rays, whose velocities are 0.78, 0.67, 0.60, 0.58, 0.49, 0.48, and 0.38 respectively of the velocity of light. There is also an indication of unreflected rays. Further experiments with much stronger fields (4000 to 5000 gauss) show them to be γ -rays. E. E. F.

1286. *X-ray Fluorescence*. **W. Kaufmann**. (Phys. Zeitschr. 14. pp. 886-887, May 1, 1918.)—Confirms E. A. Owen's rule [Abstract No. 1197 (1912)] that the absorption of fluorescent X-rays in gases is inversely proportional to the fifth power of the atomic weight of the emitting metal, and extends it to a list of twenty substances. The rule applies so long as the emitting metal and the metal contained in the absorbing gas is not the same. E. E. F.

1287. *X-ray Luminescence of Mercury Vapour*. **St. Landau and H. Piwnikiewicz**. (Phys. Zeitschr. 14. pp. 881-886, May 1, 1918.)—Hg vapour fluorescences under the influences of X-rays. The fluorescence increases with the density of the vapour, and is reduced by the presence of other gases. The increase of the luminous intensity is not simply due to increase of temperature. The spectrum is a continuous one. E. E. F.

1288. *Some Relations between Kathode and Röntgen Rays*. **R. Whiddington**. (Röntgen Soc., Journ. 9. pp. 28-28; Discussion, pp. 29-81, April, 1918.)—The need of some practical and precise method of defining the quality of a beam of Röntgen rays has long been felt, and various proposals have at different times been put forward and submitted to the test of experiments. None of the methods at present in use are satisfactory. The mode of definition now proposed has the advantage that only one observation is required, and this can be made in a few seconds. From the theoretical standpoint the method is very fundamental. The proposal is to express the quality of Röntgen rays in terms of the speed of the kathode rays striking the target within the focus tube. The apparatus consists essentially of a magnetic field arrangement to sift out kathode rays of a definite velocity from the heterogeneous bundle usually obtained when a coil is used with a soft tube, and allowing this sifted beam to fall on an antikathode. The Röntgen rays so produced can then be examined in the usual way with ionisation chamber and electroscope. It is found that so long as the speed of the particles striking the antikathode does not exceed a certain critical value (depending on the material of the radiator) there is hardly any ionisation in the ionisation chamber, but if the speed exceed this critical value there is a strong ionisation. Barkla has shown that with each element is associated a fluorescent radiation. If at this critical point the velocity of the kathode rays striking the antikathode is measured, then it is known that rays moving with this velocity emit Röntgen rays of slightly greater penetrating power than the fluorescent radiation of the element of which the radiator is composed. This critical speed is measured for several elements, and the results are given in tabular form. From these results the important conclusion is drawn that in order to excite fluorescent radiation characteristic of the element of atomic weight A , a focus bulb in which the kathode rays are moving with a speed of at least $A \times 10^9$ cm./sec. must be used. Thus in order to define at any instant the Röntgen rays all that is necessary is to determine the velocity of the kathode rays. VOL. XVI.—A.—1918.

rays by a magnetic deflection method. If in addition the absorption coefficient in aluminium of the rays is required no additional measurements are necessary ; the table given indicates the value of the absorption coefficient of the hardest rays emitted by the bulb, and it is shown that the quality of any beam of Röntgen rays is completely defined by determining the quality of its hardest component. **A. A. Campbell-Swinton.** (*Nature*, 91. p. 425, June 26, 1918.) **A. E. G.**

1289. Reflection of X-rays. J. Stark. (*Phys. Zeitschr.* 14. pp. 319–321, April 15, 1918.)—In connection with the explanation of the “diffraction” effects observed by Friedrich, Knipping and Laue [Abstract No. 1158 (1918)], as affected by the observations of Bragg and of Barkla and Martyn [Abstracts Nos. 604 and 180 (1918)], the author modifies his original hypothesis [Abstract No. 182 (1918)] and emphasises the selective scattering of X-rays rather than their selective absorption. The phenomenon is analogous to reflection from a somewhat rough surface at grazing incidence. Interference, if produced, would take place on the plan of Newton’s rings. **E. E. F.**

1290. X-ray Interference Phenomena in Non-crystalline Bodies. W. Friedrich. (*Phys. Zeitschr.* 14. pp. 817–819, April 15, 1918.)—Interference phenomena somewhat analogous to those obtained in crystals by Knipping, Laue, and the author [Abstract No. 1158 (1918)] are also obtained with some amorphous bodies. Soft wax shows several concentric rings (reproduced). Canada balsam, paraffin, paraffin oil, amber, and meerschaum show indications of rings, or at all events a distribution of intensity suggestive of diffraction. The author suggests that these rings are analogous to haloes, and that the scattering bodies are atoms, irregularly distributed. The wave-length of the X-rays would in that event have to be 10^{-9} cm. That it is an atomic phenomenon is suggested by the fact that the behaviour of liquid and solid paraffin is nearly the same. When wax is compressed in a direction normal to the rays, the rings disappear in a direction normal to the line of compression. **E. E. F.**

1291. Peripheral Effect with X-rays. W. F. D. Chambers and I. G. Rankin. (*Nature*, 91. p. 897, June 19, 1918.)—Whilst repeating the now well-known experiments of Barkla, Laue, and others, the authors accidentally met with the following effects. By inadvertence the edge of a piece of mica intercepted a direct beam of X-rays, and the recording photographic plate showed pronounced black and white bands along the X-ray shadow of the edge of mica. Further experiments with mica, glass, and metals also gave the effect, the edge of the shadow being bounded by a well-defined black band in the dark portion of the field with a light band in the lighter half. The metals tried and giving bands include lead, iron, zinc, copper, and aluminium. **E. H. B.**

1292. Reflection of X-rays. M. Laue. (*Phys. Zeitschr.* 14. pp. 421–428, May 15, 1918.)—Discusses the various alternative theories advanced by Stark, Bragg, Mandelstam, Rohmann, and others [see Abstracts Nos. 286, 604, 990–995 (1918)]. The author sees in none of these a refutation of the interference theory. The most formidable argument against the latter lies in the small effect of heat, but this applies also to the rival theories. Apart from this, the interference theory of X-ray patterns means only an extension of the ordinary theory of the grating to the case where the grating element is large compared with the wave-length. **E. E. F.**

1293. *Vibration Frequency of X-rays.* G. Zemlén. (Phys. Zeitschr. 14. pp. 428-424, May 15, 1918.)—The discovery of interference patterns due to X-rays [Abstract No. 1158 (1918)] puts the X-ray wave-length between 1 and 5×10^{-9} cm., say 8×10^{-9} cm. This means a frequency of 10^{19} . On Planck's theory of quanta, the elementary quantum of energy conveyed by X-rays should therefore be 6.55×10^{-8} erg. This can be controlled by W. Wien's data concerning the efficiency of transformation of cathode rays into X-rays, which amounts to about 1 in 1000. Now the energy of a cathode-ray particle is its charge multiplied by the p.d., both in e.s. units. It is about 8×10^{-8} , so that if $\frac{1}{1000}$ of this appears as an energy quantum of X-rays, we shall get the quantum 8×10^{-11} , which is some 800 times smaller than is required by the quanta theory. The latter can be saved by assuming that only one electron in a thousand gives rise to an X-ray pulse, or by some other assumptions, none of which, however, are entirely approved by the author. E. E. F.

1294. *X-ray Diffraction in Gypsum.* J. Herweg. (Phys. Zeitschr. 14. pp. 417-420, May 15, 1918.)—Gypsum has two cleavages with which specially simple diffractions are obtainable. They are the "silky" and the "shell" cleavage. If a fine pencil of X-rays falls on to one of these cleavage planes, making an angle of about 10° with it, a number of spots are obtained, some transmitted, some reflected, all lying on the circumference of the same circle (reproduced). The same phenomenon is obtained with an ordinary grating by allowing a beam of light to fall upon it grazingly in the direction of the rulings. The author shows that the observation can be simply and accurately explained on the interference theory. He suggests that this method may be useful for determining crystalline angles in the absence of natural angles. E. E. F.

1295. *Quantitative Relation between the Range of α -Particles and the Number of Charges emitted during Disintegration.* A. van den Broek. (Phil Mag. 25. pp. 740-742, May, 1918.)—Rutherford observed that there appears to be a relation between the period of transformation of a product and the velocity of the α -rays expelled from it. Geiger and Nuttall [see Abstract No. 168 (1912)] showed that in the great majority of cases the range of the α -particle increased with the decrease of the period of transformation. Plotting the logarithm of the range of the α -particle against the log. of the constant of transformation, the products of the uranium and radium series lie nearly on a straight line. In the Th and Ac series again most of the products lie approximately on a straight line parallel with the line showing the relation for the Ur Ra series. It is now suggested that the following relations seem to exist, first between the initial velocity of the α -rays and the number of charges expelled during disintegration: $\log V_a = A + nB$; and second, between the period of transformation and the number of charges expelled $\log \lambda = C + nD$; where B and D are general constants, A and C special constants for each series, and n is the number of charges expelled. A curve is given in which $\log V_a$ is plotted against n. A. E. G.

1296. *The Laws of Deflection of α -Particles through Large Angles.* H. Geiger and E. Marsden. (Phil. Mag. 25. pp. 604-628, April, 1918.)—In a former paper [see also Abstract No. 698 (1912)] it has been shown that in the passage of α -particles through matter the deflections are, on the average, small, and of the order of a few degrees only. It was also shown that the results could be explained on the assumption that the deflection of a single

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α -particle is the resultant of a large number of very small deflections caused by the passage of the α -particle through the successive individual atoms of the scattering substance. α -Particles are, however, sometimes turned through very large angles. This is made evident by the fact that when α -particles fall on a metal plate, a small fraction of them, about 1/8000 in the case of Pt, appear to be diffusely reflected. This amount of reflection, although small, is too large to be explained on the simple theory of scattering. The main difficulty of the present experiments has arisen from the necessity of using a very intense and narrow source of α -particles, owing to the smallness of the scattering effect. All the measurements have been carried out by observing the scintillations due to the scattered α -particles on a zinc-sulphide screen. The object is to test a theory of the atom proposed by Rutherford, the main feature of which is that there exists at the centre of the atom an intense, highly concentrated, electrical charge. The verification is based on the laws of scattering which were deduced from this theory. The following relations are verified experimentally. The number of α -particles emerging from a scattering foil at an angle ϕ with the original beam varies as $1/\sin^4(\phi/2)$, when the α -particles are counted on a definite area at a constant distance from the foil. This relation is tested for angles varying from 5° to 150° , and over this range the number of α -particles varies from 1 to 250,000 in good agreement with the theory. The number of α -particles scattered in a definite direction is directly proportional to the thickness of the scattering foil for small thicknesses. For larger thicknesses the decrease in velocity of the α -particles in the foil causes a somewhat more rapid increase in the amount of scattering. The scattering per atom of foils of different materials varies approximately as the square of the atomic weight. This relation is tested for foils of atomic weight from that of carbon to that of gold. The amount of scattering by a given foil is approximately proportional to the inverse fourth power of the velocity of the incident α -particles. This relation is tested over a range of velocities such that the number of scattered particles varies as 1:10. Quantitative experiments show that the fraction of α -particles of RaC which is scattered through an angle of 45° by a gold-foil of 1 mm. air equivalent (2.1×10^{-6} cm.) is 8.7×10^{-7} when the scattered particles are counted on a screen 1 sq. mm. area placed at a distance of 1 cm. from the scattering foil. From this figure and the foregoing results it can be calculated that the number of elementary charges composing the centre of the atom is equal to half the atomic weight.

A. E. G.

1297. Penetrating γ -Radiation. A. B. Chauveau. (Le Radium, 10. pp. 69-75, Feb., 1918.)—The author concludes that the number of ions produced per c.cm. per sec. in the air in a closed vessel, due to the penetrating γ -rays, are distributed as follows :—(1) Number due to radio-active products in suspension in the atmosphere, 0.1 to 0.2 ; (2) number due to active deposits carried to the surface of the earth by the ordinary atmospheric fall of potential or by rain, 1 to 2 ; (3) number due to the radiation from radio-active matter present in the soil, 4 to 5. The variations in the amount of penetrating radiation at the same place are presumed to be due to variations in the amount of (2).

E. M.

1298. Long-period Actinium Products. O. Hahn and M. Rothenbach. (Phys. Zeitschr. 14. pp. 409-410, May 1, 1918.)—A process for preparing pure AcX is described. Its half-period is 11.6 days, and not 10.2 days as previously assumed. Pure Radio-Ac and pure Ac were also prepared. The half-period

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of 19.5 days for the former was corroborated. Pure Ac has no activity of its own, or if it has it is only a fraction of 1 per cent. of that of its disintegration products. It may possibly emit very slow β -rays. E. E. F.

1299. *Age of Pleochroic Haloes.* J. Joly and E. Rutherford. (Phil. Mag. 25. pp. 644-657, April, 1918.)—It is now well established that the minute circular marks seen in sections of certain coloured rock minerals—notably the coloured micas—are due to the effects produced by the α -radiation of a central radio-active particle. The circular mark represents the section or projection of a sphere defined by the range in the particular containing mineral, of the most penetrating α -ray emitted. Haloes are found in which the effects of other and less penetrating α -rays of the Ur and Th families may be clearly shown. Thus in the case of the Ur derivatives, the halo may be limited by the range of RaA, by Ra emanation, by Ra, or even by Io or Ur. The halo is in every case the result of the integral actions of rays emitted since a very remote period. Haloes in the younger rocks are unknown. It is of interest to seek to estimate the time required to generate these haloes. This can be done if the following data are available :—(a) The number of α -rays which will produce a certain intensity of staining in a particular mineral. (b) The mass of a nucleus of a halo of similar or comparable intensity of staining in this same mineral, and from this an estimate of the quantity of radio-active substances which may be concerned in generating the halo. It is evident that while the numerical values involved in (a) can be obtained with a considerable degree of accuracy, certain assumptions enter into those required in (b) which render them uncertain within particular limits. Thus, while the dimensions of the nucleus may be determined with fair accuracy and its mineral nature inferred with considerable confidence there are no means, at present, of ascertaining the amount of radio-active material it contains. The present experiments and observations are confined to the brown mica, Haughtonite of Co. Carlow. In this mica haloes due to the Ur family of elements are well defined and found in every stage of development. Some of the haloes may have been formed somewhat subsequent to the crystallisation of the containing mica. From results given it would seem safe to assume 10 % of Ur as an upper limit to the amount now contained in the nuclei of the haloes in this mica. The highest of the measurements obtained point to an age not less than four hundred millions of years as the time required to generate these haloes ; in other words, as the age of the early Devonian. This is somewhat excessive compared with results of previous estimates. The treatment of the subject throughout the paper has been such as to render this a minor limit. Experiments are described which have for their aim the ascertaining the number of α -rays required to produce notable staining in Carlow mica. The following sources of error are also inquired into : (a) The nuclei are not complete nuclei. (b) The crystallographic direction in which a part of the ray traverses the mica in the case of the halo is not the same as that in which the rays move in the mica when generating the experimental darkening. (c) Nothing is known of any mode by which the mere passage of time can intensify a halo or increase the effects of original ionisation. (d) The rate of formation of the experimental staining is very fast compared with the rate of formation of the halo. (e) Exposure to light does not appear to affect one way or the other the staining produced in this mica by the α -ray. (f) Thorium is absent from these nuclei.

No Th haloes have been found in this mica.

A. E. G.

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1300. Thermal Conductivity of Crystals. N. Botez and H. Hertenstein. (Phys. Zeitschr. 14, pp. 882-886, April 15, 1918.)—Gives some results of measurements by Voigt's method of twin plates (1897). A rectangular plate is cut out of a crystal in a plane parallel to two principal axes of conductivity. The axes of co-ordinates are put parallel to the edges of the plate. Then the plate is halved by cutting along the X-axis and the two halves are made into a plate of the original size after turning one of the halves through 180° . Then, if there is any difference in the thermal conductivities along the two axes, the isothermals will show a break at the junction of the plates when the common edge is heated. Among the crystals thus observed were aragonite, topaz, baryta, vesuvian, rutile, calcspar, dolomite, quartz, beryl, and apatite. The greatest angle between the isothermals was observed in quartz (80°), in which the ratio of conductivities is 0.57. Rutile was the next ($28\frac{1}{2}^\circ$). The method is superior to that of isothermal ellipses. E. E. F.

1301. Thermal Properties and Viscosity of Gases. A. Eucken. (Phys. Zeitschr. 14, pp. 824-882, April 15, 1918.)—Examines the relation $k = Kc_v\eta$ between the thermal conductivity K , the specific heat c_v , and the viscosity η [see Abstracts Nos. 180, 517 (1912)]. Gives the thermal conductivities of pure He, H, CO, NO, N_2O , NH_3 , CH_4 , C_2H_4 , and C_2H_6 at 21° , and of these and other gases at 278° . Assuming a complete exchange of energy of molecules on collision the factor K is 2.5 for the energy of translation, 1 for the energy of rotation, and between 1 and 1.5 for the energy of oscillation. The total energy assumes a corresponding mean value. In the case of hydrogen the value of K becomes nearly 2.5 at very low temperatures, which value applies to monatomic gases. In some gases the transfer of energy is imperfect, and K falls below the calculated value. In helium the translational energy is imperfectly transferred, in CS_2 , NH_3 , and CO the rotational energy. Avogadro's number, calculated from N_2 , O_2 , Ar, and CO_2 on Chapman's theory, gives a mean value 68×10^{23} . E. E. F.

1302. Latent Heats of Chloroform and Benzene and of their Mixtures between 0° and 80° . J. Fletcher and D. Tyrer. (Chem. Soc., Journ. 108, pp. 517-528, April, 1918.)—The principle of the method used for measuring latent heats is as follows:—A known weight of the liquid is placed in a vessel immersed in a thermostat; the pressure on the vessel is maintained equal to or slightly less than the saturation vapour-pressure of the liquid, which will consequently evaporate and in so doing absorb heat from the thermostat. This absorbed heat is the latent heat measured. Instead of measuring the temperature change with a thermometer, it was determined indirectly by heating electrically the calorimeter by just so much as it was cooled in the vaporisation of the liquid, and measuring the current used in heating by means of a silver voltameter. The latent heats of pure chloroform and pure benzene, and mixtures of these liquids of varying compositions were thus determined between the ordinary temperature and the boiling-points. For any given mixture the latent heat is found to be a linear function of the temperature, and for a given temperature the latent heat is approximately a linear function of the composition. T. S. P.

1303. Latent Heat of Evaporation of Aqueous Salt Solutions. R. G. Lunn. (Phys. Soc., Proc. 25. pp. 180-191, April, 1918.)—The author has measured the heat absorbed in the vaporisation of steam for several saturated aqueous solutions of salts as well as for some unsaturated solutions of varying concentration. A jacket calorimeter method was used, a measured quantity of heat being supplied to the boiling solution by means of a small electric lamp, and the steam weighed. From the latent heats so obtained the heats of solution of the various salts are got by deducting the corresponding latent heat values for pure water. The salts investigated were sodium and potassium nitrates, sodium and potassium chlorides, and potassium chromate and dichromate. L. H. W.

1304. Thermodynamic Properties of Twelve Liquids between 20° and 80° and up to 12,000 kg./cm.². P. W. Bridgman. (Amer. Acad., Proc. 49. pp. 4-114, May, 1918.)—The author determines, by methods essentially similar to those used in his previous work, volumes, thermal dilatation, isothermal compressibility, work of compression, heat of compression, change of internal energy, and specific heats at constant pressure and volume for the following substances:—Methyl, ethyl, propyl, isobutyl and amyl alcohol, ether, acetone, carbon disulphide, phosphorus trichloride, ethyl chloride, bromide and iodide. The results are presented in numerous diagrams and their thermodynamic significance is discussed. The experiments disclose an unexpectedly complicated state of affairs at high pressures, in many cases the complete reverse of what might be expected from low-pressure observations. Thermal expansion may decrease with increasing temperature apparently for all liquids above 8000 kg./cm.²; this is shown to have a bearing on previous theories. The internal energy passes through a minimum value and increases with increasing pressure. This is because beyond a certain pressure the attractive forces do less work than is done by the external forces in compressing the molecule. In forming a theory of liquids at high pressures the shape of the molecule seems worthy of consideration because of the proximity of the molecules at high pressures. The author shows in detail the plausibility of such speculations. It would appear from the author's work that at high pressures, pressure is caused by something additional to the kinetic reactions of the standard theory. H. S. R.

1305. Temperature of a Wedge-shaped Cavity and its Use as a Black Body. B. J. Spence. (Astrophys. Journ. 87. pp. 194-197, April, 1918.)—Mendenhall has previously described the properties of the radiation emitted by the interior of a wedge-shaped cavity at various temperatures [Abstract No. 770 (1911)]. If the temperature of the wedge could be determined by means of a thermo-couple inserted somewhere within the wedge, its usefulness would be much increased; e.g. it could be used as a black body for the calibration of optical pyrometers. Again, we may determine the relation between the true temperature of a substance and its corresponding black-body temperature, using a pyrometer to determine the black-body temperature; the thermo-couple would give the true temperature. To measure the temperature of the wedge a thermo-couple with very fine wires was introduced into a piece of very fine-bored and thin-walled silica tubing of the same length as the Pt-foil used for the wedge. The foil (8.5 × 2 cm.) was folded, and, at the folded part, wrapped completely round the silica tube, the projecting part of the foil forming the wedge. Experiments on the melting-point of gold showed that the couple gave accurately to at least 1 in 1000, the temperature of the

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wedge, also that the radiation from the interior of the wedge approximated more closely to that of a black body at the melting-point of gold than did the black-body furnace. Experiments on the difference between the true wedge temperature as determined by the thermo-couple and the corresponding black-body temperature indicated by the radiation from the exterior of the wedge were carried out for temperatures between 985°C . and 1580°C . The results are tabulated and agree with those of Waidner and Burgess and also those of Mendenhall.

A. W.

1306. *Principle of Least Work of Deformation*. T. Pöschl. (Phys. Zeitschr. 14. pp. 410–412, May 1, 1918.)—Referring to H. Lorenz's deduction of the principle of least work by Ritz's method [Abstract No. 540 (1918)], the author gives a more direct proof that the internal work is a homogeneous quadratic function of the displacements, and the external work a homogeneous linear function.

E. E. F.

1307. *The Constant in the Radiation Law*. J. de Boissoudy. (Comptes Rendus, 156. pp. 1864–1866, May 5, 1918.)—A preceding note by the author contains the substitution of a minimum energy term in Planck's classical hypothesis, to render applicable the principle of equipartition. The formulæ of Wien and Lorentz for the energy of black radiation are then discussed. On the above assumption the law of Stefan-Boltzmann, viz. $W = uT^4$ is obtained, where u is the constant and T the temperature. The experimental data of Féry and Dreqq are next discussed, and the value of the constant u is given; its value is higher than those on the Planck and Kurlbaum formulæ.

H. H. Ho.

1308. *Radiation Measurements*. II. W. Gerlach. (Ann. d. Physik, 41. 1. pp. 99–114, May 22, 1918.)—Discusses the various determinations of the radiation constant and defends the author's value of Feb., 1912, with the addition ± 1 per cent. The following five recent values are given for this constant σ :—

Shakespeare (Nov., 1911).....	5.67×10^{-12}
Gerlach (Feb., 1912)	5.90 "
Puccianti (May, 1912)	5.96 "
Westphal (Oct., 1912)	5.54 "
Keene (Dec., 1912).....	5.89 "

[See Abstracts Nos. 1280 (1912), 99 and 1176 (1918).]

E. H. B.

1309. *Theory of the Accumulation of Energy with Intermittent Illumination, and Basis of the Law of Dark Radiation*. E. Marx. (Ann. d. Physik, 41. 1. pp. 161–190, May 22, 1918.)—Experiments by the author, in conjunction with K. Lichtenecker, on the accumulation of light-energy when employing intermittent illumination, lead to the conclusion that the amount of electronic emission from Elster and Geitel's potassium cells is completely independent of the division of the illuminating energy. Numerical details of the experiments are given. The result that an electro-optical effect is obtained by a light intensity of 6×10^{-8} erg/sec. cm^2 is worthy of note with respect to the theory of the mechanism of emission and absorption, being directly concerned with the fundamentals of the law of dark radiation. Assuming that the electron which is liberated by the illumination of the potassium cells originates from a resonated oscillation, the energy necessary for liberation

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must be withdrawn from the incident light. A mathematical treatment then follows for the case when the max. energy is abstracted from the light, *i.e.* when complete resonance takes place, and also for the case when the electron's oscillations are damped by the radiation. The experimental results are then compared with Lorentz's value for the limiting energy of the incident light below which no electro-optical effect can take place, assuming that the light-energy is distributed uniformly over the wave-front and throughout the volume. The comparison shows that electro-optical effects have been obtained with light of much smaller energy than the above theory demands. After considering emission theories, the author remarks that the electro-optical experiments are explicable on the old wave theory with certain assumptions, and if the damping term in the fundamental electronic equation be retained. The latter involves concentration zones, but these are compatible with the wave theory, while it is probable that the measured intensity of light is an average value from waves of varying amplitude. Lorentz has therefore proposed that the max. intensities possible when an average is assumed may account for the electro-optical phenomena. The author then gives a mathematical discussion of the problem from the standpoint of concentration zones. The fundamental principles involved in the accumulation of energy by exposure to Röntgen rays are next considered, and the same difficulties encountered as in the case of electro-optical effects. The different hypotheses as to the nature of the concentration zones are then critically examined. The cause of no gaseous ionisation taking place when ordinary light traverses gases, as well as the ionisation effects produced by ultra-violet light, are investigated, and the conclusion drawn that in the assumption of concentration zones, whose volumes depend on the wavelengths, lies the possibility of explaining gaseous ionisation by different light rays. The following are the final conclusions:—(1) The negative results of experiments to establish an accumulation with very feeble light-energy, using intermittent illumination of duration 10^{-7} sec., and the appearance of an electro-optical effect at 10^{-8} erg/cm.² sec., are, on the assumption of an isotropic light distribution, not in agreement with the fundamental electronic equation on the one hand and with Planck's radiation law on the other. (2) The assumption of concentration zones in the transversely vibrating light rays, of volume equal to the active volume of the vibrating electron, can be defended on the fundamental equation without contradicting the electro-optical phenomena. It was found that the energy portion of the zones was only 0.01-0.001 % of the average light-energy. This renders possible the explanation of concentration zones as abnormal amplitudes on the old wave theory. On the other hand, the possibility arises of accepting Einstein's interpretation of the zones as light-quanta. (3) Only by entire omission of the damping term can harmony be preserved with the experimental results when isotropic light-distribution is retained. Planck has thereby founded his explanation of dark radiation, but the difficulties are so considerable that this explanation appears to possess no special advantage over the other. (4) The production of cathode rays by γ - or Röntgen-rays appears incapable of explanation without the assumption of concentration zones, even if the wave surfaces are of sharp conical form. (5) The failure of ordinary light to produce gaseous ionisation is inexplicable when the damping term is omitted. (6) J. J. Thomson's interpretation of the concentration zones as necessitated by the æther thrust due to the sudden emission of an energy element renders possible an experimental criterion for the existence of concentration zones. H. H. HO.

SOUND.

1310. *Relative Sound Intensities and the Rayleigh Disc.* G. W. Stewart and H. Stiles. (Phys. Rev. 1. Ser. 2. pp. 809-815, April, 1913.)—The absolute intensity of sound has been measured principally in four ways, viz. :—(1) by the Rayleigh disc [Zernov, Abstract No. 1128 (1908)] ; (2) by the increased pressure at a reflecting wall [Altberg, Abstract No. 1471 (1904) and Zernov, Abstract No. 2054 (1906)] ; (3) by measuring pressure-changes at nodes of stationary waves by a manometer (Raps, Ann. d. Physik, 86. p. 278, 1889) ; and (4) by optical interference methods (Raps, Ann. d. Physik, 50. p. 198, 1898, and Sharpe, Science, 9. 1910, 1909, p. 808).

In some of the experiments just referred to, varying measurable sound intensities were produced, but in such a manner as to be unavailable for the calibration of intensity-measuring devices of various kinds. Indeed, the authors found no record of a successful effort to produce known varying intensities available for testing purposes. The inverse square law is quite inaccurate even out of doors.

The theory of the acoustic shadow [see Abstract No. 885 (1912)] produced at any distance from a rigid sphere with the source located on the sphere suggested a method of producing known variations of intensity, and thus obtaining a calibration device for sound-measuring apparatus. This plan was adopted, the sphere being of cement 5 cm. thick and 185.9 cm. circumference. The sound was from an electric fork, of 256 per sec., and issued from an opening in the sphere about 5 cm. diam. The detector was a Rayleigh disc, having a mirror 0.6 cm. in. diam. of very thin microscope cover glass suspended by a quartz fibre, its period being 6 secs. The results show that this method of producing relative sound intensities is a practicable one, and that the theory of the sound shadow is correct if it be assumed that the deflection of the Rayleigh disc is proportional to the energy. E. H. B.

1311. *Sensibility to Pitch.* II. H. Muraoka. (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 19-81, Oct., 1912.)—In the first part of this research dealing with the range from $n = 128$ to 1280 per sec., the following conclusions were drawn : If dn denote the increment of frequency which is perceptible, then with a purely psychophysical test $dn/n = 0.0029$; with a second or interchanging test, $dn/n = 0.0020$; while with a mechanical test $dn/n = 0.0011$. The present, or second, part of the research was undertaken to extend the examination to higher and lower regions of pitch. On account of many difficulties this has, however, not been quite accomplished. The author finds that it is scarcely possible at present to speak of an exact value of dn/n , so much depends on the manner of making the test. Values of 0.0081 and 0.00095 are here obtained by various methods. [See Abstract No. 105 (1911).] E. H. B.

1312. *Artificial Hiss.* E. R. Marle. (Nature, 91. pp. 871-872, June 12, 1918.)—In reply to a previous query as to the artificial production of a hiss, it is here suggested that a piece of sheet iron or compressed charcoal should be held in the small pointed flame of an ordinary foot blowpipe when the air supply is somewhat in excess of the needs of the flame. By adjusting the

supply of gas, the pressure of air and the position of the iron sheet, sounds can be obtained varying from *f* to *s* or *sh*. The oxyhydrogen flame with slight excess of oxygen is even better. The air entering a vacuum desiccator through a narrow stopcock gives a fairly good *s* sound.

H. L. Kiek (Ibid.) points out that a loud hissing noise accompanies the passing of an electric arc across the gap in such a lamp as is used for optical lanterns. The actual "hiss" sounds much more of a sibilant than an "f," such as is produced by a current of air forced under pressure through a small opening. **E. B. Titchener**. (Ibid. p. 451.) E. H. B.

1313. *Mechanical Maintenance of Vibrations of Bars, Forks, and Plates*. **H. Magunna**. (Comptes Rendus, 156. pp. 1878-1874, May 5, 1918.)—Describes a method of maintenance of vibration of forks, etc., by endless belts which are rosined and thus act like a violin bow. Instead of the belt a cylindrical drum or a flat disc may be used. [For photograph of apparatus and description of its application to musical-spark emission, see Rev. Élect. 19. pp. 484-485, May 2, 1918.] E. H. B.

1314. *Origin of Subjective Combination Tones*. **J. Peterson**. (Ann. d. Physik, 40. 4. pp. 815-816, April 15, 1918.)—Discusses the various views held by different physicists, and cites a previous publication of the author's to the effect that the conditions favourable to the production of combinational tones are found in the liquids of the cochlea. [See Abstract No. 911 (1911).] E. H. B.

1315. *Complex and Intermittent Sounds*. **Marage**. (Comptes Rendus, 156. pp. 155-158, Jan. 13, 1918.)—Discusses by aid of certain vibration-traces the education of deaf mutes, pointing out that simple vibrations should precede the more complex and intermittent ones that are needed in ordinary speech. E. H. B.

1316. *Theory of Edge Tones*. **W. König**. (Phys. Zeitschr. 18. pp. 1058-1054; Discussion, pp. 1054-1055, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—A discussion of the production of tones in cases where a blade-shaped stream of air strikes an edge or corner or pipe lips without a pipe space. If *a* is the distance from the opening through which the air issues to the edge which it strikes and the speed of the flow is *v*, it is calculated that the frequency of the tone is $v/2a$ nearly. E. H. B.

1317. *Thunder*. **W. Schmidt**. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2045-2062, Nov., 1912.)—This is a preliminary paper describing a registering apparatus which gives a pressure-time curve for thunder. The paper includes a reproduction of the wavy curve thus obtained. E. H. B.

1318. *Objective Combination Tones*. **E. Waetzmann** and **G. Mücke**. (Deutsch. Phys. Gesell., Verh. 15. 8. p. 848, April 30, 1918.)—Corrects the description of Fig. 2 in the paper to which this is a supplement [see Abstract No. 649 (1918)]. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1319. *Collisions between Gas Molecules and Slow Electrons.* J. Franck and G. Hertz. (Deutsch. Phys. Gesell., Verh. 15. 9. 878-890, May 15, 1913.)—An experimental research, of which the chief results may be thus summarised :—(1) In agreement with Lenard it is found that the free paths of the electrons at speeds between 10 and 2 volts are very near those of free paths calculated from the kinetic gas theory, so that the electron affinity and electric charge appear to have no marked influence at these speeds. (2) It is shown that in collisions between electron rays of this range of speeds and molecules of helium and hydrogen the electrons are reflected with a relatively small loss of energy. (3) From these facts certain theoretical conceptions are developed. [See Abstracts Nos. 2958 (1904) and 840 (1910).]

E. H. B.

1320. *Electric Conduction by Free Electrons and Carriers.* II. P. Lenard. (Ann. d. Physik, 41. 1. pp. 58-98, May 22, 1913.)—The second part of the whole theoretical and mathematical treatment of this subject, with tables and many footnotes, being abstracts from a lecture before the Heidelberg Academy of Sciences. [See Abstract No. 1180 (1913).]

E. H. B.

1321. *Initial Energies of Photoelectrically-liberated Electrons.* H. J. van der Bijl. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 880-847, April 30, 1913.)—The object of this work was to show that many determinations of initial energies were lacking in various essential respects. In particular the following effects have been here investigated : (1) The hindrance to electron reflection due to the auxiliary field ; (2) the contact potential between the plates ; (3) the glow discharge. The auxiliary field may affect the initial energies by 40 volts or more.

E. H. B.

1322. *Electron Theory of Metals.* K. F. Herzfeld. (Ann. d. Physik, 41. 1. pp. 27-52, May 22, 1913.)—Mathematical treatment.

E. H. B.

1323. *The Large Ions in the Atmosphere.* H. Kennedy. (Royal Irish Acad., Proc. 82. pp. 1-6, June, 1913.)—In a previous paper some measurements were recorded of the number of ions found in the atmosphere in the city of Dublin. [See Abstract No. 218 (1913).] As it seemed probable that this number was largely influenced by the town site the further experiments described in the present paper were made on a site close to the sea-shore at Dalkey, 8 miles to the south-east of Dublin. The mean number of large ions present was found to be less than 1000 per c.cm. as compared with 16,000 found in Dublin. The only occasion on which a large number of ions was found was on a day when the wind was blowing directly from Dublin. The author therefore concludes that by far the greater part of the large ions existing in the atmosphere of the city are due to local combustion products. He considers it probable that large ions are formed for the most part by the combination of a small ion with one of the minute drops formed in the cooling gases

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rising from sources of combustion, and that they are identical with Aitken's "condensation nuclei." The number of small ions found in the present experiments was 700 per c.cm. This is a much larger number than that found in Dublin, and is in good agreement with the results obtained in general by observers using the Ebert apparatus. It is considered probable that the small number found in the city was due to the combination of the greater part of the small ions with the gaseous products to form large ions.

J. S. DI.

DISCHARGE AND OSCILLATIONS.

1324. *Influence of the Valency of the Metal upon the Photoelectric Effect of Metallic Compounds.* G. A. Dima. (Comptes Rendus, 156. pp. 1366-1368, May 5, 1913.)—Hallwachs' phenomenon is first cited, viz., that almost all negatively charged bodies emit negative charges when exposed to ultra-violet light. The author has made a series of preliminary experiments in air at ordinary pressures, to ascertain whether a metal of different valency in an analogous compound influences the emission of electric charges. The apparatus employed was a condenser one of whose coatings was charged to a constant positive potential of about 100 volts, while the other was connected to the substance to be examined. The latter combination was connected either to earth or to a quadrant electrometer, while readings were taken over a given interval. A quartz mercury lamp was the source for the ultra-violet light, variations of the lamp with time being taken into account. The substances examined were chemically pure, and as powder were contained in silver capsules so that conditions were the same for all. Compression of the powder was found to have great influence upon the emission, this growing more or less rapidly with compression, but tending towards a limit. A table is given for a large number of stable substances, and in every case the compound in which the metal has the smallest valency appears to have the greatest photoelectric power. On the electronic theory this is explained by the fact that where the metal is monovalent it has a greater positive charge, thereby producing the most feeble emission of negative corpuscles.

H. H. HO.

1325. *Reflection Coefficient of Metallic Films. Longitudinal Action and Penetration in Photo-electricity.* A. Partzsch and W. Hallwachs. (Ann. d. Physik, 41. 2. pp. 247-272, June 8, 1913.)—An experimental research of which the chief results are as follows:—(1) A series of kathode-deposited Pt-films of 1 to 50 μ thickness were examined for the passage of light both forwards and backwards, the incident, reflected and transmitted beams being all measured. By illumination from behind 40 per cent. more light remained in the film than by illumination from the front. The reflection coefficient from quartz to platinum at first decreases with increasing thickness of film from zero; at about 8 μ a minimum occurs; at about 7 μ the original value recurring. This result is in accord with theory. (2) A longitudinal action, if usually present, is of a smaller order of magnitude than has hitherto been supposed. [See Abstracts Nos. 550 and 1408 (1912), and 669 (1913).]

E. H. B.

1326. *Elster and Geitel Potassium-Hydride Cell.* E. Marx and K. Lichtenecker. (Ann. d. Physik, 41. 1. pp. 124-160, May 22, 1913.)—Describes an experimental investigation of the influence of subdivision of
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the time of illumination on the emission of electrons in an Elster and Geitel potassium-hydride cell for very small incident light-energy. The conclusion is reached that within the limits of error (1 or 2 %) a variation of the illumination time in the ratio 4.88×10^{-8} sec. to 1.46×10^{-7} sec., or 1 : 80,000, with the same incident energy of light per sec. of 0.5 erg/sec./cm.² produced no effect on the quantity of the electrons emitted. [See Abstracts Nos. 1087 (1911) and next Abstract.] A. W.

1327. Sensibility of Photoelectric Cells. J. G. Kemp. (Phys. Rev. 1. Ser. 2. pp. 274-298, April, 1918.)—Gives a systematic quantitative study of the conditions of sensibility of photoelectric cells of alkali metals with hydrogen, and a determination of the work required to draw an electron out of an atom. The following facts are established for the type of cell employed : (1) Owing to the low melting-point of Cs the use of this metal in photoelectric cells for photometric use is very impractical. (2) The temperature at which it is best to operate a potassium cell is about 25° C. (3) Cooling the potassium cell much below 25° C. does not increase its sensitiveness. (4) The sensibility of a potassium cell can be increased more than 100 times by the process of forming the hydride surface. (5) The distance between the electrodes for best sensitiveness is about 0.5 cm. (6) The hydrogen gas pressure at which the cell is most sensitive lies between 2 and 8 mm. of Hg. (7) The p.d. applied to the electrodes for most sensitive conditions is about 380 volts. (8) The minimum energy required to produce an ion by collision was calculated from the data and found to be of the order 1.77×10^{-11} erg, while the theoretical value determined is 1.68×10^{-11} erg. (9) Assuming that the straight lines obtained which show the relation between current and intensity of illumination hold for exceedingly small intensities, then by using a tilted electroscope of sensibility 10^{-16} amp. a candle could be detected at a distance of 2.7 miles. This indicates that it is highly probable that a photoelectric cell could be used in astrophotometric work. [See Abstracts Nos. 1579 (1909), 958 (1910), and 1881 (1911).] A. W.

1328. Pressure of Kathode Rays. E. v. Angerer. (Ann. d. Physik, 41. 1. pp. 1-26, May 22, 1918.)—The work of earlier experimenters, such as Crookes, Puluj, Riecke, and Starke, is first referred to. In the present experiments an attempt is made to repeat the researches of Starke, but the work is not complete. The apparatus employed and method of carrying out the experiments are described. From the results it is concluded that it is possible to measure, to some per cent., the pressure of the kathode rays, but it does not appear probable that measurements can be made of sufficient accuracy to determine from the same data the value of e/m , or to make a decision between the relative and absolute theory. As a side issue it is found that it is possible to maintain a vacuum of 8×10^{-7} mm. Hg by means of charcoal in a Dewar flask containing liquid air, and to measure the vacuum by a Knudsen manometer. With a Wehnelt kathode in action a vacuum of 4×10^{-8} mm. Hg can be maintained. A. E. G.

1329. Occurrence of Neon in Vacuum Tubes containing Hydrogen. I. Masson. (Chem. Soc., Proc. 29. p. 288, June 28, 1918.)—Experiments to test the results of Collie and Patterson [Abstract No. 1086 (1918)] have yielded independent evidence of the fact that neon appears after the passage of an electrical discharge through a vessel containing a gas previously free from neon. When pure dry hydrogen is sparked in a discharge tube bearing VOL. XVI.—A.—1918.

a perforated aluminium disc kathode and having a vacuous jacket surrounding it, after a time neon ceases to be formed. On then admitting a mixture of oxygen and hydrogen and passing the discharge, the tube appears to be rendered "active" once more, for thereafter neon is steadily produced when hydrogen is sparked. In all these experiments hydrogen accumulated in the initially vacuous jacket and had apparently passed through from the discharge tube. Quantities up to about $\frac{1}{2}$ c.cm are so obtained. This gas is found to contain no other, except CO in small and varying amounts. A. E. G.

1330. *Presence of Neon in Hydrogen after the Passage of the Electric Discharge through the latter at Low Pressures.* II. J. N. Collie and H. S. Patterson. (Chem. Soc., Proc. 29. pp. 217-221, June 28, 1918.)—Since the previous communication [Abstract No. 1086 (1918)] it has been proved that electrodes are not necessary for the production of helium and neon by the electric discharge through hydrogen, for if a powerful oscillating discharge be passed through a coil of wire wound round a glass bulb containing a little hydrogen, He and Ne can be detected in the residual hydrogen. It is necessary to free the gas as far as possible from Hg vapour. An apparatus is also made wherein the tube through which the discharge takes place is surrounded by a vacuous outer tube. The wires connected to the electrodes in the inner tube pass through the outer tube in glass tubes, so that there could be no discharge from any electrodes in the outer vessel. Various experiments have also been made with electrodes other than Al; the results obtained with copper being particularly interesting, since the hydrogen seems to disappear more rapidly than with aluminium electrodes, the splashed copper being in parts of a black colour. Briefly stated the results are as follows:—Electrodes are apparently not necessary for the production of He and Ne. Hydrogen in considerable quantities can be made apparently to disappear entirely in tubes through which a heavy discharge passes. A gas that gives a carbon spectrum is produced in the tubes. It entirely disappears when sparked in contact with Hg. It is not readily condensed by charcoal cooled in liquid air, nor easily oxidised by sparking with oxygen. It is possible that this gas may be the same as that discovered by J. J. Thomson and called by him X₂. When Cu, Pt, Pd, or Mg are splashed off in an ordinary vacuum tube containing hydrogen, Collie finds something is produced that, after dissolving in aqua regia, gives a precipitate in acid solution with barium chloride. In an appended note Collie gives the following results which probably account for this precipitate. Copper electrodes are used and the solution of the splash in acids is evaporated in silica vessels. No precipitate is obtained. The same tube is used again, and the solution of the splash is divided in half; that evaporated in glass test tubes gives a precipitate, but no precipitate is obtained with that evaporated in silica vessels. It is also suggested that it is possible that the silver solder employed to seal the Cu electrodes to the Pt may account for the precipitate. A. E. G.

1331. *Electric Brush Discharge in Water and Salt Solutions.* H. Smith. (Phil. Mag. 25. pp. 461-475, April, 1918.)—The electric arc burning under liquids has been investigated by Konen [Abstract No. 688 (1908)]; the spark discharge by Wilsing, Lockyer, Hale, Konen and Finger. If the secondary of an induction coil is connected to two electrodes immersed in a liquid, one electrode being a metal plate and the other a wire, enclosed in glass, with only the extreme end exposed, a luminous *brush* is obtained at this enclosed electrode. This brush was examined by Konen in a large number of liquids

and weak solutions. The brush and also the capillary discharge, in distilled water and in a few weak solutions, are further dealt with in the present paper. The character of the discharge varies considerably with the conditions under which it is produced. The spectra observed in the brush and capillary discharge are those of: *Hydrogen*.—Series spectrum, and many-lined or secondary spectrum. *Oxygen*.—Series spectrum, and many-lined or elementary-line spectrum. *Electrode*.—Spark-lines of Pt. *Solute*.—Complete spectrum, in visible part, of the metal. *Impurities*.—D-lines, red and green doublets of sodium; blue line ($\lambda 4227$) and occasionally the red and green bands of calcium. The series spectrum of hydrogen in both the capillary and brush discharge increases with increase of current density, while the secondary spectrum decreases in relative intensity to the series lines. The series lines broaden considerably with the condensed discharges, and the relative intensity of the lines falls off towards the violet. The series spectrum of oxygen appears only with the higher-current-density discharges, being brighter with higher current density. The elementary-line spectrum appears in the brush with the feebler discharges only, its brightness also depending on the nature of the solution. It appears in the spectrum of the capillary, in the capillary discharge, only very faintly if at all, but in the discharge in dilute sulphuric acid it is the most important part of the spectrum of the bubble which forms at each end of the capillary. The lines of the metal of the dissolved salt appear in the brush. In the case of lithium their relative intensity varies with the salt used and also with the current. In weak solutions the metal lines are destroyed by the heavier condensed discharges. The metal lines appear very feebly in a capillary, and they are produced strongly only in the immediate neighbourhood of a metal electrode. The spark-lines of Pt appear with the condensed discharges when a spark-gap is used.

A. W.

1932. *The Theory of the Glow Discharge from Wires*. J. S. Townsend, (Electrician, 71. pp. 848-850, June 6, 1918.)—Making the hypothesis that the conductivity of a gas is produced by the ions generated by the collisions of positive and negative ions with the molecules of the gas, the author investigates the potential gradient required to produce a discharge from the surface of a wire. If p be the pressure of the air between two concentric cylinders of radii a and A respectively and p/k be the pressure between two larger cylinders whose radii are ka and kA , it is proved that the charge Q per unit length when a discharge takes place is the same in the two cases; in other words, the charge Q is a function of pa . It is shown that Watson's experiments at different pressures verify this theorem. Assuming that all the ions are generated within the corona, the radius of which is C , and that the electric strength of air at normal temperature and pressure is 80 kilovolts per cm. we get $2Q/c = 80 = V/[c \log(b/a)] = R_1 a/c$, where b is the radius of the outer cylinder and R_1 is the potential gradient at the surface of the inner cylinder. Hence $R_1 a = 80c$ and $c - a = a(R_1/80 - 1)$. The mean value of R is approximately $(R_1 + 80)/2$, and this force ought to produce a force sufficient to cause a discharge between parallel plates at a distance $c - a$. Now from Baille's experimental results for parallel plates $V = 80x + 1.85$, where x is the distance between them. Hence $V/x = 80 + 1.85/x$, and thus—

$$(R_1 + 80)/2 = 80 + 1.85/(c - a) = 80 + 1.85/[R_1/80 - 1] a.$$

Finally we get $R_1 = 80 + 9/\sqrt{a}$. But since $R_1 a$ is a function of ap , we get for the critical force R_1 at the surface of a wire $R_1 = p(80 + 9/\sqrt{ap})$, where p is

in atmos., which is in practically exact agreement with Peek's formula. A theoretical investigation of the currents between a wire of fixed diam. and cylinders coaxial with it is also given, the conclusions being compared with Almy's experimental results. A. R.

1333. *Potential Disturbances due to Sounds placed in the Lighted Positive Column.* R. Reiger. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 271-285, April 30, 1918.)—The paper deals with the subject in the following sections:—Theoretical considerations; alteration of the potential through the introduction of glass rods into the discharge; alteration of potential through the introduction of metal rods into the discharge; distribution of potential in the neighbourhood of a metal rod; dependence on the pressure of the anode- and kathode-falls at the sound; dependence of the anode- and kathode-falls on the surface of the introduced rod; distribution of potential in the neighbourhood of a glass rod. The most important results are as follows:—The potential is raised by the introduction of such foreign bodies as sounds. The rise in potential increases with increasing pressure and with the thickness of the sound. Thin rods of metal and glass bring about, in general, similar disturbance; on the other hand, thick rods of metal produce much the greater disturbance. In the neighbourhood of a sound there is a marked fall of potential both on anode and kathode side, the former being much the larger. In potential measurements the diam. of the sound should be as small as possible. With double sounds, *i.e.* sounds placed a small distance apart, the disturbance of potential is very important. A. E. G.

1334. *Potential Disturbances due to Glowing Sounds in the Lighted Positive Column.* R. Reiger. (Deutsch. Phys. Gesell., Verh. 15. 9. pp. 855-868, May 15, 1918.)—Comparisons are made with sounds consisting of a glowing clean Pt-wire and a Pt-wire coated with CaO and the results are shown graphically, the heating currents being plotted as abscissae and the p.d.'s as ordinates. These curves clearly show the superposition of pure temperature effects and the emission of electrons. On the anode side of the sound, in addition to the temperature influence a large decrease in the potential takes place. This increases with decreasing pressure since the emission of electrons increases as the pressure is lowered. On the kathode side there is an increase of potential due to the increase of the anode-fall. The dependence of the alteration of potential on the current through the gas is considered, and it is shown that the most important result is the small nature of the alteration. In considering the potential-distribution in the neighbourhood of the glowing sound it is found that the kathode-fall vanishes on the anode side of the sound. The general conclusion is that glowing sounds with a CaO coating are of little use for practical measurements of potential on account of the considerable disturbances of potential they produce in the immediate vicinity. A. E. G.

1335. *Decrement Paper.* L. Isakow. (Phys. Zeitschr. 14. pp. 456-457, May 15, 1918.)—Describes and reproduces a co-ordinate paper, so divided that when all observations are plotted the whole resonance curve takes the form of two straight lines which intersect in the point of resonance. Within the limits of validity of the theory of Bjerknes all points must lie on these straight lines, and deviations may be smoothed out by a ruler. Systematic deviations prove that the decrements are not constant. E. E. F.

1336. *Absorption of Short Electric Waves by Air and Water-vapour.* J. E. Ives. (Phil. Mag. 25. pp. 702-710, May, 1918.)—It is well known that wireless telegraph signals can be sent farther at night than in the day. One of the suggestions that have been made to explain this fact is that the air may absorb more of the energy of the waves during the daytime than it does during the night; the absorption of the waves being supposed to be due to the ions produced, either in the lower or in the upper layers of the atmosphere, by the action of the sunlight. It was this fact and the suggested explanation of it which led to the present research. The results of the experiments show that for electric waves about 10 cm. long passing through air at pressures ranging from 76 cm. to 0.001 cm. of mercury, and through water-vapour at pressures ranging from 1.50 cm. to 0.015 cm., the absorption of the energy of the waves by the air, if it exists, must be less than one-tenth of one per cent. per cm. This was also found to be true when the air was ionised by radium chloride placed in open vessels within the tube. This would indicate that the ionisation of the air by radium produces, if any, only a very small effect upon its absorbing power for electric waves about 10 cm. long. [See Abstract No. 655 (1908).] E. H. B.

1337. *Abnormal Dispersion of Short Electric Waves.* F. Eckert. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 807-829, April 30, 1918. Extract from Dissertation, Berlin.)—An oscillator was used like that of Lebedew and measurements were carried out with the four wave-lengths of 88, 57, 87, and 17.5 mm. The chief results were as follows:—(1) Contrary to the work of some others, the reflection from metals agreed well with theory and in whichever plane the electric vector occurred. (2) By water the reflection coefficient, the transparency and the temperature coefficient of the absorption for the above waves were determined. (3) From these the index of refraction, the absorption coefficient, and the abnormal dispersion of water in the above region were derived. (4) For the same region the absorption per cm. in methyl-, ethyl-, propyl- and isobutylalcohol and glycerine were measured, and the abnormal dispersion of these substances confirmed. (5) For methylalcohol the index of refraction was determined, and on the basis of the value of the absorption coefficient the wave-length of the longest natural vibration obtained. [See Abstracts Nos. 1840 (1905) and 516 (1911).] *Erratum* (Ibid. p. 422, May 30, 1918). E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1338. *Resistance of Heated Graphite and Carbon.* E. F. Northrup. (Metallurgical and Chem. Engin. 11. p. 276, May, 1918.)—A rod of Acheson graphite hardly changed its resistance while being heated up to 1500° C. That carbon (e.g. an electric light carbon) has a negative temperature-coefficient is demonstrated by fixing a rod of carbon and a rod of graphite in holes drilled into two plates of graphite which are joined to a transformer. Though the two rods were in parallel, the graphite rod quickly became incandescent, whilst the carbon rod heated up slowly, finally to become more brilliantly incandescent than the former. H. B.

1339. *Change in Electrical Resistance due to Pressure at Low Temperature.* H. Kamerlingh Onnes and B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 947-952, April 24, 1918. Communication No. 1826 from the Phys. Lab., Leiden.)—In this paper the result is given of a first
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investigation of the change of resistance under the influence of uniform hydrostatic pressure. The measurement of the pressure coefficient, γ , at low temperatures is very difficult, for the temperature coefficient is then so great that even the smallest fluctuations of temperature can greatly affect the resistance, and thus variations of resistance may occur which completely obscure the whole phenomenon of variation with pressure. Experiments were made on a turning of lead with liquid oxygen and liquid hydrogen as compressing liquids. For the pressure coefficient Lisell gives, $\gamma = -1.44 \times 10^{-4}$ at $T = 278^\circ$ abs. The authors find from their measurements :

$$\gamma = -2.25 \times 10^{-4} \text{ at } T = 90^\circ \text{ abs.,}$$

and—

$$\gamma = -1.7 \times 10^{-5} \text{ at } T = 20.8^\circ \text{ abs.,}$$

so that the pressure coefficient is somewhat greater at the lower temperatures. The increase between 278° A. and 90° A. changes again to a diminution. The accuracy of the measurements is, however, not sufficient for any significance to be attributed to this diminution. As to the decrease $-\Delta w$ in the resistance for $p = 100$ atmos. it is found to approximate to zero at the lower temperatures. Thus for lead—

278° abs. for $p = 100$ atmos. — $\Delta w = 0.017$ ohm.

90° abs. " " — $\Delta w = 0.008$ "

20.8° abs. " " — $\Delta w = 0.001$ "

J. J. S.

1340. *Electric Resistance of Soap Films.* A. Hagenbach. (Archives des Sciences, 85. pp. 829-889, April, 1918.)—Using a fresh solution of oleate of soda, concentration 1 : 40 with 1/4 of glycerine (Boys' recipe), the author finds at 28.5 to 24° the results in the following table :—

Colours.	Thicknesses by Index of Refraction.	Relative Thicknesses.	Relative Conductivities.	Conductivities Thicknesses
Purple, 4th order	552 μ	1	1	1
Blue sky, 2nd "	217	0.385	0.69	1.79
Violet, 2nd "	197	0.349	0.595	1.71
Brown, 1st "	119	0.210	0.548	2.58
Yellow, 1st "	102	0.180	0.487	2.71
White, 1st "	89.9	0.159	0.408	2.57
Black	12	0.0212	0.128	6.08
	(Reinold & Rücker)			

Experiments with Boys' rainbow cup are also described.

E. H. B.

1341. *Thermoelectric Power of Silicon.* F. Fischer, R. Lepsius, and E. Baerwind. (Phys. Zeitschr. 14. pp. 439-446, May 15, 1918.)—A large number of specimens of silicon were examined as to their thermoelectric powers. It was found that Si specimens may be highly positive towards copper, and also highly negative. An apparatus was designed for the rapid examination of irregular pieces, and several methods were worked out for converting "positive" into "negative" sorts, and the reverse. The negative character appears to be due to the addition of SiO_2 . On withdrawing the dissolved silica, the positive character reappears. By combining $-\text{Si}$ and $+\text{Si}$, thermo-elements giving as much as 1000 microvolts per degree can be constructed.

E. E. F.

1342. *Standard Cells*. L. W. Öholm. (Act. Soc. Sci. Fennicæ, 41. No. 1. pp. 1-118, Helsingfors, 1912.)—Gives the results of numerous experiments on standard cells having cadmium amalgam for the negative electrode, mercury for the positive electrode, and chlorides, bromides, iodides, and sulphates, of cadmium and mercury for electrolytes and depolarisers respectively. The e.m.f.'s of these cells and their temperature coefficients are given in the following table :—

Cell.	Electromotive Force.
Chloride	$E_t = 0.67180 - 0.000074 (t - 18^\circ) - 0.0000015 (t - 18^\circ)^2$
Bromide	$E_t = 0.55916 - 0.000866 (t - 18^\circ) - 0.0000046 (t - 18^\circ)^2$
Iodide	$E_t = 0.41470 + 0.000862 (t - 18^\circ) - 0.0000008 (t - 18^\circ)^2$
Sulphate	$E_t = 1.0186 - 0.000088 (t - 20^\circ) - 0.00000065 (t - 20^\circ)^2$

[It is probable that the e.m.f.'s should be reduced in the ratio 1.0183/1.0186 for the values to be in international volts.—F. E. S.] When the concentration of a solution is changed, the e.m.f. also changes. The relation between concentration and e.m.f. is shown in the following table :—

Concentration of Solution.	Electromotive Force.			
	CdCl ₂ .	CdBr ₂ .	CdI ₂ .	CdSO ₄ .
Saturated at 4° C.	0.6722	—	—	1.0191
8.84 normal	0.67949	—	—	—
2 "	0.67840	0.57052	0.41456	1.08804
1 "	0.70885	0.58410	0.48090	1.06016
0.5 "	0.71459	0.59586	0.44290	1.05778
0.25 "	0.72728	0.60648	0.46800	1.06509
0.10 "	0.74470	0.62299	0.46500	1.07526

The constancy and reproducibility of the cells were found to be very good. In the case of the sulphate cells a number, made up with dilute solutions, have fallen in e.m.f. to a marked extent, and the fall is somewhat proportional to the dilution of the solution.

F. E. S.

1343. *Theory of Thomson-effect*. H. Hörig. (Phys. Zeitschr. 14. pp. 446-447, May 15, 1913.)—Emphasises the necessity for full experimental data bearing upon the Thomson-effect, and describes some experiments made with a silver tube 60 cm. long and 4.2 cm. external diam., heated by means of an alternating current of 600 \sim to about 150° C. The observed e.m.f. does not exceed 10^{-6} volt per 1 deg. C. The electron theories would indicate larger values. But if Kelvin's $\int \sigma dT$ is identified with the e.m.f. of the temperature gradient (which the author does not admit), then the e.m.f. for silver would be 2.6×10^{-6} volt per degree.

E. E. F.

1344. *E.M.F. produced by the Flow of Electrolyte Solutions through Capillary Tubes*. L. Riéty. (Comptes Rendus, 156. pp. 1868-1870, May 5, 1913.)—In preceding notes [see Abstract No. 1098 (1912)] the author has described a process for the measurement of the e.m.f.'s during filtration of concentrated solutions of copper and zinc salts, and has shown how to deduce from the

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results obtained the potential difference of glass—electrolyte. Measurements have been made of aqueous solutions of the chloride, nitrate, sulphate, and carbonate of potassium, hydrochloric acid, and sulphuric acid, in the tube which served for the previous experiments. The non-polarisable electrodes were silver wires, coated with fused silver chloride according to Grumbach's directions. Numerical results are given, and from viscosity and conductivity measurements the p.d. between glass and electrolyte is calculated on Helmholtz's theory. For all these solutions the electrolyte possesses a greater potential than glass. From a study of potassium nitrate between wide concentration limits, the difference of contact potential appears to decrease constantly as the electrolyte concentration increases, and presents no minimum as in the case of copper and zinc sulphates. For dilute solutions the p.d. is much greater for potassium salts than those of copper or zinc.

H. H. Ho.

1345. Precision Resistances for High-frequency Alternating Currents. K. W. Wagner and A. Wertheimer. (*Elektrotechn. Zeitschr.* 84. pp. 618–616, May 29, and pp. 649–652, June 5, 1918. Communication from the Kaiserl. Telegraphen-Versuchsamt.)—A consideration of the construction of resistances for use with alternating current when high precision in the measurements is required. By a suitable arrangement of the winding it is shown that the time constant of most resistances can be reduced to a negligible quantity. The means found coincide to some extent with those recently communicated by Curtis and Grover [see Abstract No. 504 (1918)]. However, in the present paper the chief results are shown graphically, and some idea is given of the uniformity to be expected when coils (intended to have negligible time constants) are produced on a manufacturing scale.

F. E. S.

1346. The Vibration Electrometer and its Application to Alternating-current Measurement. H. Greinacher. (*Archiv f. Elektrotechnik*, 1. No. 11. pp. 471–476, 1918.)—The author first describes the mode of working of the vibration electrometer. After remarking that a leaf electroscope or a quadrant electrometer gives a constant deflection with an alternating-current as with a direct one, the author points out that it is otherwise with the string electrometer designed specially for radio-activity or ionisation measurements. When the alternating current has not too high a frequency, the threads follow momentarily the rapid current-changes, and are therefore set in vibration. The author, from this observation, conceived the idea of using the vibration electrometer as a null instrument for alternating-current measurement. The Wulf double-thread electrometer was first employed, although later the author designed a special apparatus for the purpose. Results are described, first when the electrometer is vibrating, and second, when used as a null instrument under the ordinary Wheatstone-bridge conditions, whereby the advantage is obtained of a sensitiveness extending throughout very wide limits. The author remarks that any other statical instrument of sufficient sensitiveness could be used, e.g. a leaf electroscope, but points out the advantages derived from the vibration method. A special disposition is described, whereby an auxiliary battery is avoided. The vibration method may naturally be employed in such cases as the determination of electrolyte resistance, capacity measurement, &c. The author then describes an investigation in variable magnetic and electric fields. The frequency limits of the vibration electrometer are next investi-

gated and tabulated. It follows from the table that the normal vibration limit for quartz threads is fairly restricted. A new form of vibration electrometer is then described, whereby the disadvantage of the quartz thread instrument is overcome, this being the disintegration of the metallic surfaces, whereby the threads conduct badly and are finally useless. A platinum thread is utilised, and the instrument so designed as to be of very small dimensions. The same sensitiveness is attained as in Wulf's electrometer.

H. H. Ho.

1347. *New Sensitive Relay*. H. Rohmann. (Phys. Zeitschr. 14. pp. 850-852, April 15, 1918.)—Describes an arrangement for utilising and enlarging small deflections, say, of a moving-coil galvanometer, without reducing the sensitiveness of the measuring system. In a coil attached to the moving system an alternating current is induced whose intensity depends upon the position of the coil, and which takes up the expenditure of work. The alternating current traverses a hot-wire instrument or works a relay. The coil is closed by means of a condenser. Its circuit is tuned to the frequency of an alternating field provided by a fixed coil. The phase difference being 90° , the electrodynamic force is zero, while the transfer of energy is a maximum. The induced current is, for small deflections, proportional to the deflection. It is conveyed by silver strips which take currents up to $\frac{1}{2}$ amp. With a current in the moving coil amounting to 0.1 micro-amp., the author obtained a deflection in a hot-wire ammeter representing 0.1 watt.

E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

1348. *Magnetic Behaviour of Iron and Nickel under the Oscillatory Discharge from a Condenser*. E. W. Marchant. (Roy. Soc., Proc. Ser. A. 88. pp. 254-280, May 8, 1918.)—The chief object of the experiments described was the determination of the relation between magnetising force and permeability when iron or nickel is subjected to alternating magnetisation obtained from the oscillatory discharge of a condenser, especially with a view to finding the permeability with large magnetising forces. The method employed was to photograph the image of the spark produced by the condenser discharge reflected from a revolving mirror. The following are the author's conclusions:—(1) With an air condenser, the capacity of which was measured ballistically, and an air-core self-induction coil of known value, the frequency of the oscillations of the condenser discharge agrees with the values calculated by Kelvin's formula. (2) The resistance of a spark between spheres of 1 in. diam., 2.5 mm. apart, when the max. current is greater than 200 amps. does not exceed 2 ohms. With a max. current greater than 500 amps. the resistance does not exceed 0.75 ohm. (3) When an iron wire is inserted in the self-induction coil, the time for each consecutive half-oscillation increases with the duration of the discharge. (4) With a series of discharges from a given condenser in which the max. value of the magnetising current varies, the time for the first half-oscillation decreases with increase in the strength of the current. (5) The increase in the time of a half-oscillation with the duration of the discharge is due to the increase in the permeability of the iron, as the current, and consequently the magnetising force, dies away. (6) The permeability of the iron wires, calculated from the observed increase in the self-induction of the coil decreases with increase of the magnetising force. The curve connecting μ , the "effective" perme-

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ability with H , the magnetising force, agrees with that obtained on the assumption that the permeability of the iron is the same as with a steady magnetising force. (7) The insertion of an iron-wire core into the coil causes more rapid damping, due to eddy-current and hysteresis losses, chiefly the former. (8) The "effective" permeability of thick wires (0.12 cm. diam.) is nearly equal to that of thin wires with the same magnetising force (between 500 and 5000 gauss). The causes of this are: (a) The increase in the "skin" effect with thick wire diminishes the apparent permeability; (b) the increased dissipation of energy with thick wires reduces the max. value of the magnetising force, and thus increases the apparent permeability; (c) the self-demagnetising force due to leakage from the surface of the wire decreases the actual magnetising force acting on the iron, thus increasing the permeability of the iron. (9) With cores of solid iron inserted into the self-induction coil, the duration of the discharge is less than with other cores; the self-induction of the coil with solid iron cores is about 15 % greater than with air cores. (10) With nickel wire cores the effects are similar to those with iron, but of less intensity, the permeability of the nickel wire with rapidly oscillating magnetic force being similar to that with steady magnetising forces. (11) With cores of insulated copper wires no changes in damping or self-induction are apparent. J. J. S.

1349. Demagnetisation Factors of Elliptic Cylinders. H. du Bois. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 805-806, April 80, 1918.)—The expression for the demagnetisation factor N of an elliptic cylinder, with semi-axes a and b and of length c , can be integrated, and gives $N_x = 4\pi b/(a+b)$, $N_y = 4\pi a/(a+b)$, and, for a long cylinder, $N_z = 0$. Taking the axis-ratio m , these expressions become $4\pi/m + 1$, $4\pi m/m + 1$, and 0, and their sum is equal to 4π [see also Abstract No. 1860 (1908)]. These extremely simple formulæ are derived in the usual manner from the general potential theory of the ellipsoid. G. E. A.

1350. Formulæ employed in Determinations of Susceptibility. A. Guillet. (Journ. de Physique, 8. Ser. 5. pp. 824-888, April, 1918.)—Starting with the Newtonian result for the force inside a homogeneous sphere of attracting material, two centres of force are taken as the basis for solution of problems in electricity and magnetism. The formulæ employed by Curie, Gouy, and Quincke in their magnetic researches are then established. G. E. A.

1351. Hall-effect and Change in Resistance in a Magnetic Field at Low Temperatures. H. Kamerlingh Onnes and B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 981-987, April 24, 1918. Communication No. 182a from the Phys. Lab., Leiden.)—The resistance of solid mercury was measured and found to be 7.97 ohms at $T = 287.8^\circ$ abs., 0.1014 at $T = 20.8^\circ$, and 0.0618 at $T = 14.5^\circ$. An increase of resistance occurs in the magnetic field. With H (in gauss) = 10,000 and $T = 20.8^\circ$ abs. the increase in resistance $\Delta w/w = +1.5 \times 10^{-3}$. In the same field with $T = 14.5^\circ$ abs., $\Delta w/w = +6 \times 10^{-3}$. At these temperatures the temperature coefficient of resistance is very great. The large increase occasioned by lowering the temperature from 20° to 14° abs. is very striking. Observations were made with a plate of pure nickel 0.058 mm. thick. The Hall-effect for Ni decreases as the temperature falls from ordinary values as previously found by A. W. Smith [see Abstract No. 448 (1910)]. According to A. Kundt the Hall-effect for ferromagnetic substances is proportional to the magnetisation and not to the field. Hence saturation occurs for the Hall-effect, or the curves showing

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Hall-effect as a function of the field should show a bend. At 290° abs. the authors' measurements show this bend at about 5000 to 6000 gauss. At the lower temperatures 90° , 20.8° , and 14.5° abs. there is no decided bend visible with $H < 10,400$. At 14.5° abs. the Hall-effect is strictly proportional to the field as is also the case at 20.8° abs. as far as $H = 9060$. At 90° abs. the Hall coefficient is a linear function of the field, diminishing as the field increases [Abstracts Nos. 694-698 (1918)]. For the Hall coefficient in very weak fields the relation $R_0 = c\epsilon^T$ holds. As previously found by other observers, there is an increase in the resistance of nickel in weaker fields ($H < 8000$); in stronger fields the resistance diminishes. A wire of pure iron was examined (impurity about 0.18 %). At $T = 288^{\circ}$ abs. the resistance w was 11.18 ohms, at 90° abs. 2.225, and at 14.5° abs. 1.124. The temperature coefficient is very small in the liquid-hydrogen region. At 288° abs. the resistance increases in weak fields and decreases in fields greater than 7000. At liquid-hydrogen temperatures this behaviour is reversed, for the resistance diminishes in weaker fields and increases when $H > 7000$. There is a neutral zone at about $H = 7000$.

J. J. S.

1852. *Hall-effect for Gold-Silver Alloys at Temperatures down to the Melting-point of Hydrogen.* B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 988-996, April 25, 1918. Communication No. 182c from the Physical Lab., Leiden.)—The observations on the Hall-effect in Au-Ag alloys previously described [Abstracts Nos. 697, 698 (1918)] were continued with three other alloys containing a greater percentage of silver. The values of the Hall-effect at temperatures 290° , 90° , 20.8° , and 14.5° abs. and with different magnetic fields are given. The addition of a small quantity of gold to pure silver causes a very large decrease in the conductivity. An admixture of 2 atomic per cent. of gold reduces the conductivity from 71.10×10^6 to 1.85×10^6 ; the unit being the reciprocal of the resistance in ohms of a 1-cm. edged cube. When silver is gradually added to pure gold the Hall coefficient at low temperatures diminishes at first rapidly and then more slowly until with a mixture of about equal quantities of Au and Ag a large change in the composition occasions only a very small change in the Hall-effect. The lower the temperature the steeper is the descent of the curve showing the Hall coefficient as a function of the atomic percentage of Ag. When a 2 % admixture of silver is added to pure gold the Hall coefficient diminishes

at $T = 20.8^{\circ}$ abs. from 9.8×10^{-4} to 6.7×10^{-4} ;

at $T = 90^{\circ}$ abs. from 7.6×10^{-4} to 6.6×10^{-4} ;

at $T = 290^{\circ}$ abs. from 7.2×10^{-4} to 6.1×10^{-4} .

Hence a small Ag impurity in gold occasions only a small variation of the Hall-effect at $T = 290^{\circ}$ abs., which, however, becomes more appreciable at lower temperatures. With Ag and Au the Hall coefficient increases as the temperature falls. At low temperatures alloys with more than 2 % of Ag show a distinct diminution of the Hall-effect, which is greatest for alloys of medium concentrations.

J. J. S.

1853. *Hall-effect in Tellurium and Bismuth at Low Temperatures.* H. Kamerlingh Onnes and B. Beckman. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 997-1008, April 24, 1918. Communication No. 182d from the Physical Lab., Leiden.)—The Hall-effect was measured for two plates of tellurium at temperatures down to the melting-point of hydrogen.

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With the first plate the resistance increased considerably at low temperatures. At $T = 290^\circ$ abs. the specific resistance was 1.95×10^8 c.g.s. At 20.8° abs. the resistance was about three times as great. The resistance of the second plate attained a maximum at about 40° to 60° abs. For Te_{PI} (the first plate) the Hall coefficient, R , was 89.1 at 290° abs., and 48.1 at 20.8° abs. For Te_{PII} the values of R were 185.5 at 291° abs. and 214.5 at 20.8° abs. At any definite temperature R is practically constant for various fields; at lower temperatures there is an indication that R diminishes somewhat in the stronger fields. For both plates the Hall-effect increases at lower temperatures, while the ratio $R_{290^\circ}/R_{290^\circ}$ is the same. This is very remarkable, for the plates are completely different with regard to their specific resistance, resistance temperature coefficient, and absolute magnitude of the Hall-effect.

Experiments were continued with Bi crystals [Abstract No. 694 (1918)], and results are given for the case in which the field is parallel, and the main current perpendicular, to the axis. At ordinary temperature and in weak fields R_H is negative. In stronger fields R_H becomes positive. The critical negative values found by Becquerel are much greater than those of the authors, and Becquerel found zero to be attained in much stronger fields. For $H = 1000$, $R = -0.05$ for $T = 290^\circ$ abs.; $R = +8.4$ for $T = 90^\circ$ abs.; $R = +8.11$ for $T = 20.8^\circ$ abs.; $R = +2.88$ for $T = 14.5^\circ$ abs. J. J. S.

1354. *Production of Strong and Uniform Magnetic Fields.* H. du Bois. (Deutsch. Phys. Gesell., Verh. 15. 8. pp. 292-304, April 30, 1918.)—Discusses mathematically the magnetic fields obtained with pole-pieces of different forms; also deals with the question of cooling of the electromagnet. A. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1355. *Metallic Beryllium (Glucinum).* F. Fichter and K. Jablczynski. (Ber. Deut. Chem. Gesell. 46. pp. 1604-1611, 1918.)—Glucinum is best obtained by the electrolysis of a fusion containing 1 mol. of sodium fluoride to 2 mols. of glucinum fluoride [compare Lebeau, Abstract No. 802 (1898)], using a nickel crucible as kathode, a carbon rod anode, and a current strength of 7-10 amps. at 15 volts. The temperature must not rise too high, otherwise an alloy of glucinum and nickel is formed. The metal is isolated from the fusion by dissolving the salts in water, the solution being prevented from becoming acid by the addition of ammonia and by repeated renewal of the water. The crystals of glucinum so obtained are freed from admixed oxide by centrifugalisation in a mixture of ethylene dibromide and alcohol (D 1.95); they have $D = 1.842$. The small crystals so obtained cannot be melted together under ordinary conditions, owing to the coating of oxide formed preventing coalescence; it is necessary to form cylinders by compression, and then heat them up in an electric vacuum furnace or in one containing hydrogen at 11-15 mm. The melting-point is $1280^{\circ} \pm 20^{\circ}$. The regulus of metal has hardness between 6 and 7, and scratches glass; the freshly filed metal is steel-grey in colour. At the ordinary temperature it is brittle, but at higher temperatures ductile. The specific resistance (referred to a wire of 1 m. length and 1 mm. cross-section) at 20° is 18.47 ohms. The resistance to the action of water is caused by a surface film of oxide. As anode in a solution of sodium ammonium phosphate it acts as a valve electrode, similarly to aluminium. It is not so readily attacked by alkalis as is usually stated to be the case. T. S. P.

1356. *Chemical Reactions and Radii of Curvature.* G. Reboul. (Comptes Rendus, 156. pp. 1876-1878, May 5, 1918.)—The author describes further experiments made under the conditions previously employed [see Abstract No. 729 (1913)]. A copper wire 1.5 mm. in diam. is attacked far more readily when alone than when placed near another wire, 0.15 mm. thick. The latter thus exercises a protecting action on the former. A strip of copper is similarly protected by a thin wire. The attacking gas seems to be attracted to the points where the radius of curvature is least; the extent of the protective effect of these points increases as the pressure of the gas is diminished, and with pressures of the order 0.05 mm. amounts to several centimetres. There is thus an apparent distillation of the active substance of the gas to the points with the greatest curvatures. T. H. P.

1357. *Use of Anti-piping Thermit in Casting Steel Ingots.* E. A. Beck. (Amer. Inst. Mining Engin., Bull. No. 76. pp. 649-656, April, 1918.)—Some interesting details concerning the Thermit process for producing sound ingots, mentioned in Abstract No. 279 (1918), are described. The object of the method is not to heat the steel and keep it fluid, but to create a stirring action and promote the removal of gases, thus preventing the formation of blow-holes and pipes. In top pouring the can must be introduced somewhat earlier (when the crust has extended over about one-half the surface of the ingot) than in bottom pouring, because of the colder steel being at the bottom. After the cessation of the agitation the steel sinks in the mould,

and it is advisable to follow up this shrinkage. The material is improved in quality by an increase in density and by a transfer of the segregated area towards the top surface of the ingot. At the same time an increase of from 8 to 10 % in the yield is obtained. Tables are appended showing the uniformity in composition and mechanical properties of plates rolled from ingots treated by this process.

F. C. A. H. L.

1358. Commercial Production of Sound Steel Ingots. E. Gathmann. (Amer. Inst. Mining Engin., Bull. No. 76. pp. 649-668, April, 1918.)—The solidification of an ingot of steel previously "killed" depends entirely upon the shape of the mould and the thickness of its walls. In the author's method of casting, the cooling of the upper part of the ingot is slow in comparison with the lower part. This is effected by making the mould walls thick and heavy for about 85 per cent. of the height of the ingot from the bottom. The upper portion of the walls are made thin and less heat-absorptive. By this means the pipe and segregate are confined to the upper 10 % of the ingot. Special stripping apparatus has been designed so that the output is probably increased under the new methods. The average discard has been reduced to 12 %, as compared with 85 to 40 % by the older methods.

F. C. A. H. L.

1359. Triferrocarbide (Cementite). O. Ruff and E. Gersten. (Ber. Deut. Chem. Gesell. 46. pp. 394-400, Feb. 22, 1918. Chem. News, 107. p. 262, May 28, 1918. Abstract.)—According to Jermilow the molecular heat of formation of Fe_3C should be + 2.27 cals., according to the authors' determination of 1912, - 15.1 cals. But they had not themselves determined the heat of oxidation of FeO to $\frac{1}{3}\text{Fe}_2\text{O}_3$, which they now find to be + 28.6 \pm 1.8 cals., in fair agreement with le Chatelier, 25.7, whose value they had previously accepted. Making this correction, the molecular heat of the formation of Fe_3C would be - 15.8 \pm 0.2 cals.

H. B.

1360. Carbides of Manganese and Nickel. O. Ruff and E. Gersten. (Ber. Deut. Chem. Gesell. 46. pp. 400-418, Feb. 22, 1918. Chem. News, 107. p. 252, May 28, 1918. Abstract.)— Mn_3C is prepared by heating in a crucible (electric vacuum furnace) for 20 minutes manganese (reduced by thermit) and carbon at 1600° C. and 20 mm. pressure. The carbide forms soft glistening needles and fibres, hardness intermediate between talc and gypsum; the hardness of alloys containing Mn_3C and Fe_3C (also soft) may be due to the solid solutions. The molecular heat of combustion of Mn_3C to Mn_2O_3 is 410.9 \pm 2 cals., the molecular heat of the formation of Mn_3C is 12.9 \pm 2 cals. (le Chatelier 9.84 cals.). The Ni_3C is formed chiefly at 2100°, but it is unstable and decomposes again on cooling; the molecular heat of formation of Ni_3C is - 894 \pm 10 cals., of Fe_3C - 15.8 \pm 0.2 cals.

H. B.

1361. Rate of Rusting of Iron and Steel. J. Aston and C. F. Burgess. (Amer. Electrochem. Soc., Trans. 22. pp. 219-240, 1912.)—Corrosion tests have been made on several commercial grades of iron and steel in the form of bars and sheets with and without scale. The tests took the form of exposure of a set of samples to atmospheric weathering, while other specimens were exposed to the exhaust of a chemical laboratory. The total period of test was 800 days, after which the depth of pitting was determined by grinding and weighing the metal removed. This weight added to the corrosion losses gives a value which has been called by the authors "equivalent corrosion," while the ratio of this value to the actual corrosion gives the pitting factor.

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Generally speaking, the results show that the acid corrosion test (exposure to 20 % sulphuric acid) gives no idea of the behaviour of the metals in practice. The corrosive action of the atmosphere is largely influenced by fumes and smoke and by the season of the year, the loss being greatest in spring. Scale does not retard rusting. Pitting is responsible for a deterioration which is three times as great as that caused by uniform rusting. Photomicrographs fail to show any marked connection between the presence of impurities and heterogeneity of structure and rate of corrosion. The authors consider that the service conditions constitute a vital factor in the corrosion of iron, and that it is just as important to study the conditions of use as to study the materials themselves.

F. C. A. H. L.

1362. Transformations of Iron-Silicon Alloys. G. Charpy and A. Cornu. (Comptes Rendus, 156. pp. 1240-1248, April 21, 1918.)—Dilatation experiments on alloys containing 0.1 % C, 0.8 % Mn, and 0.2 to 4.5 % Si show that between these limits the addition of silicon to iron does not affect the dilatation coefficient between 0° and 700° C. The temperature of the anomaly in the dilatation curve between 800° and 900° C. is not displaced, but the magnitude decreases as the Si increases, and disappears at 1.8 % Si. Low-carbon alloys containing over 1.8 % Si show an almost rectilinear dilatation curve between 0° and 900° C. A similar result is obtained with nickel, but in this case the anomaly is not effaced but merely displaced in the scale of temperature. In a second series containing 0.85 % C and 0.8 % Mn, similar results have been obtained, but the effects are much less marked, 4.5 % Si being necessary to efface the anomaly. Comparison of the cooling- and dilatation-curves of a soft steel and a low-carbon alloy containing 8.5 % Si indicates that the point A₂ subsists after the points A₁ and A₃ have disappeared, so that it cannot be a residue of the latter transformations.

F. C. A. H. L.

1363. Transformations of Iron-Silicon Alloys. E. Vigoroux. (Comptes Rendus, 156. pp. 1874-1876, May 5, 1918.)—Interest in the work of Charpy and Cornu [see preceding Abstract] has led to the publication of heating curves of pure iron-silicon alloys containing up to 7 % Si. None of the alloys showed A₁ or A₃, but addition of 0.5 % Si raised A₂ by 14° C., which increment was continued up to 8 % Si. Between 8 and 4 % Si the temperature was steady, after which it was again increased up to about 7 % Si, when the point disappeared altogether.

F. C. A. H. L.

1364. Metallographic Investigation of the System: Thallium and Tellurium. M. Chikashige. (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 5-12, Sept., 1912.)—Investigation of the freezing-point curve shows that thallium and tellurium form two compounds, namely, Te₂Tl₃ and TeTl. The former corresponds with a maximum in the curve at 428°, whilst the latter corresponds with a break in the curve at 805° and 40.5 % Te. The eutectic point lies at 200° and 58.5 % Te. The alloys separate into two liquid layers between the limits 1.5 and 24 % Te at 898°. Solid solutions are only formed by the compound Te₂Tl₃ with 5.5 % of Tl. This compound is very brittle, whilst the compound TeTl, which forms long needles, is much less so.

T. S. P.

1365. Fixation of Nitrogen by Barium Oxide and Charcoal. T. Ewan and T. Napier. (Soc. Chem. Ind., Journ. 82. pp. 467-474, May 15, 1918. Paper read before the Scottish Section.)—That a mixture of baryta and carbon, when calcined in air, readily combined with nitrogen, was observed by Margueritte

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and de Sourdeval in 1860 : J. B. Readman technically carried out the reaction about 1895. The authors have since 1909, unknowingly at first, been working on the lines of Kühling and Berkhold, heating a mixture of 2 parts of barium carbonate and 1 of charcoal in an electric Heraeus furnace while passing nitrogen through the tube. The absorption of N begins between 900° and 980°, and increases with rising temperature, 2½ per cent. of the nitrogen used being fixed at 960° and 10 per cent. at 1000°. The products are BaO, Ba(CN)₂, and BaCN₂; the reactions are very complicated, and not more than half the barium oxide can be converted in this way into a nitrogen compound. The two reactions $\text{BaO} + 2\text{C} + \text{N}_2 \rightleftharpoons \text{BaCN}_2 + \text{CO}$ and $\text{BaO} + 8\text{C} + \text{N}_2 \rightleftharpoons \text{Ba(CN)}_2 + \text{CO}$ seem to be reversible, but a less active compound BaO, Ba(CN)₂, also appears to be formed, and the reaction $\text{Ba(CN)}_2 = \text{BaCN}_2 + \text{C}$, decomposition of the cyanide by heat, is not reversible. Some barium carbide is probably formed out of BaO and C before the absorption of N begins. Barium ferrocyanide, heated alone or mixed with charcoal, yields a mixture of barium cyanide and cyanamide. The experiments, which were made in the laboratory of the Cassel Cyanide Co., do not fully explain the phenomena. H. B.

1366. *Hydrogen from Water and Coal from Cellulose at High Pressures and Temperatures.* F. Bergius. (Soc. Chem. Ind., Journ. 82. pp. 462-465; Discussion, pp. 465-467, May 15, 1918.)—Further particulars of the researches noticed in Abstract No. 1769 (1912). The author and Specht apply higher temperatures, 840°, and therefore much higher pressures than Stein and Klason had done. Iron heated with water is completely turned into a finely-divided powder of Fe₃O₄, not only on the surface, and a hydrogen of 99.95 per cent. is produced which need not be compressed for transport. When water is sealed up with cellulose, peat, etc., it remains liquid and retains its high specific heat; hence local superheating is prevented, the liquid water acting as a material for storing heat, and the temperature can easily be kept constant throughout the mass. Cellulose and water at 840° turn in twelve hours into a black powder containing 84 per cent. of C, 5 of H, and 11 of O; some CO₂ is also found in the vessel. The H percentage is as high as in bituminous coal. Eight hours' heating at 840° yields the same result as 64 hours at 810°; thus a rise of 30 deg. accelerates the reaction 8 = 2³ times, or an elevation of the temperature by 10 deg. doubles the speed of the reaction. It is not possible apparently to raise the carbon percentage above 84 by these means, and the resulting dry powder does not resemble coal unless it be heated for hours to 840°, while being submitted to very high mechanical pressure; pressure alone at ordinary temperature will not yield a product like anthracite, though it does so in Nature in the course of thousands or millions of years. The author distinguishes carbonisation from formation of anthracite; he considers the latter as a pressure effect. The vessels, up to 200 galls. capacity, are made of special steel and are fitted with joints after Kirchenbauer, used by Haber and le Rossignol, consisting of cone-shaped ends, clamped and forced together by a screw, there being merely a circular line of contact; these joints keep tight at 400° and 150 atmos. for several weeks. The discussion concerned mainly the nature of the resulting coal. H. B.

1367. *Molecular Refraction.* G. Pólya. (Phys. Zeitschr. 14. pp. 852-856, April 15, 1918.)—Examines the formula $M/d \times (D - 1)/D$, in which M is the molecular weight, d the density, and D the dielectric constant. This is closely related to the modern formula involving the refractive index instead
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of the dielectric constant. The constancy of the formula is tested by an imaginary cycle of experiments, in which the condenser containing the substance is first discharged in a reversible manner; then a chemical reaction is made to take place in the dielectric; then the electrification is restored while compensating electrostriction by suitable pressure; and finally the reaction is reversed and the work recovered. If the amount of work in the second stage is A_0 and in the fourth stage A_p , the surface density σ and the p.d. V , then $A_p = A_0 + \frac{1}{2}V\sigma - \frac{1}{2}V'\sigma$. Since in the limit the reversible max. work is a measure of the "avidity" of the reactions, the reaction is accelerated in an electric field if the amount of electric energy is thereby increased, and *vice versa*.
E. E. F.

1368. Influence of Diffusion on E.M.F. produced in Solutions by Centrifugal Action. W. L. Miller. (Amer. Electrochem. Soc., Trans. 21. pp. 209-217, 1912.)—The author has calculated the influence of diffusion on the e.m.f. produced in Tolman's experiments [Abstract No. 178 (1911)] by centrifugal action, and shows that it is not large enough to influence the results, as after 15 minutes it would only amount to 0.021 millivolt.
T. M. L.

1369. Orientation of Liquid-crystals by Plates of Mica. C. Mauguin (Comptes Rendus, 156. pp. 1246-1247, April 21, 1918.)—When azoxyanisol is melted between cleavage plates of mica the liquid-crystals develop in a peculiar manner. Taking the well-known star-figure which is produced on striking a mica-plate with a blunt point, the 6 rays of the star are (1) parallel to the axis of the crystal, (2) at 60° to the right and left. The liquid-crystal sets itself with its optic axis parallel to one of the secondary rays of the lower plate of mica (e.g. the one to the right of the axis of the mica-crystal), but on passing through the film of liquid-crystal the orientation gradually changes until at the upper surface the optic axis is parallel to the other secondary ray of the mica (e.g. the one to the left of the axis of the mica-crystal). These two rays are therefore not identical in their properties, since, when the cleavage is made, an identical behaviour is possessed by the one to the right on the lower surface of the cleavage and the one to the left on the upper surface of the cleavage, as viewed from above the composite-plate. If viewed from the cleavage-plane itself the two rays with identical properties, would, of course, be oriented in the same way.
T. M. L.

1370. Influence of Colloids and Fine Suspensions on the Solubility of Gases in Water. III. Solubility of Carbon Dioxide at Pressures lower than Atmospheric. A. Findlay and T. Williams. (Chem. Soc., Journ. 108. pp. 686-645, April, 1918.)—By extending the investigations of Findlay and Creighton [Abstract No. 1167 (1910)] to lower pressures confirmation has been obtained of the view that in presence of colloids the solubility-curve of a gas under varying pressure exhibits a minimum or else falls with increasing pressure to a constant value. Thus in the case of dextrin, the solubility of CO_2 , which was steady at higher pressures, is shown to increase at the lower pressures now investigated.
T. M. L.

1371. New Electric Properties of a Semipermeable Membrane of Copper Ferrocyanide. R. Beutner. (Journ. Phys. Chem. 17. pp. 844-860, April, 1918.)—(1) A precipitation membrane of copper ferrocyanide behaves like an electrode, reversible for monovalent positive ions of different kinds. (2) The e.m.f. of the system $\text{K}_4\text{Fe}(\text{CN})_6$ aq. sol.—precipitation membrane— CuSO_4 aq. sol. is due to a concentration cell with K^+ ions. The K^+ salt concentration
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of the CuSO_4 solution is due to K_2SO_4 , which is generated by the formation and steady increase in thickness of the membrane. The K^+ concentration in the boundary region of the CuSO_4 solution, which is essential for the e.m.f., depends mainly on the velocity of diffusion into that part of the CuSO_4 solution which is free from K_2SO_4 .
T. M. L.

1372. *Electro-analysis of Copper, Antimony, Bismuth, and Tin with Acidified Chloride Electrolytes.* E. P. Schoch and D. J. Brown. (Amer. Electrochem. Soc., Trans. 22. pp. 265-275, 1912.)—The authors find that Cu, Sb, Bi, and Sn may be deposited quantitatively and in good form from hydrochloric acid electrolytes if suitable reducing agents (formalin, hydroxylamine hydrochloride, oxalic acid, etc.) are added to them. It is possible to separate copper from tin and estimate both from the same sample of electrolyte, using the method of graded potential, thus reducing the otherwise troublesome analysis of bronze to a very simple operation. Metals with a potential more positive than that of tin do not interfere with the estimation of copper by this method. These methods present many advantages over older methods. The electrolytes are easily prepared, because all of the metals are soluble in *aqua regia*, and all of their compounds are soluble either in this reagent or in hydrochloric acid. The electrolytes are free from odour, and the results indicate that the deposits are probably free from inclusions. Rotating electrodes are employed and the methods are rapid. Full experimental details are given. [See Abstract No. 1782 (1908).]
T. S. P.

1373. *Concentration-changes in the Electrolysis of Copper-sulphate Solutions.* C. W. Bennett and C. O. Brown. (Journ. Phys. Chem. 17. pp. 873-885, May 15, 1913.)—It has been noticed previously [see Abstract No. 1294 (1912)] in the electrolysis of copper-sulphate solutions with a rotating copper cathode, that the potential-drop across the cell, with constant current, increases with an increase in the speed of rotation. This observation has been confirmed for variations in the speed of rotation from 1000 to 5000 revs. per min. Investigation of the various factors which may cause an increase in potential, showed that the increase was due to a rise in the potential at the rotating cathode, where the equilibrium $\text{Cu} + \text{Cu}^{++} \rightleftharpoons 2\text{Cu}^+$ exists. As the rotation increases and the stirring becomes more efficient, the cuprous ions are removed faster and faster, and the solubility of the copper is therefore increased, giving rise to a higher voltage. The increase in the drop of potential between the electrodes is also partly due, in all probability, to an increased resistance of the electrolyte. When a solution of cuprous chloride in hydrochloric acid is used there is a decrease, instead of an increase, in potential. This is due to the removal of the cupric ions at the electrode, which are in equilibrium with the cuprous ions and the copper of the electrode. The potential of a rotating electrode in nitric acid diminishes with increasing rate of rotation, owing to the increasingly efficient removal of the film of nitrous acid, whereby the tendency of the copper to dissolve is diminished, and therefore its voltage. The solution pressure of a metal is increased if the size of its crystals be decreased. This is made apparent by an increase in the potential of the metal as the crystal size is decreased, by hammering or burnishing, for example. It is also shown by the fact that fine-grained metal (electrolytic copper) is electro-positive to more coarsely crystalline metal (cast copper).
T. S. P.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1918.

GENERAL PHYSICS.

1567. *New Form of Printing Chronograph.* W. Gaertner. (Science, 87. pp. 641-642, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—The design is for an instrument capable of recording time in minutes, seconds, and hundredths of seconds, by printing the records in figures on a strip of paper. The minute and second wheels are rotated by two specially designed electromagnets which operate on pawls and ratchet-wheels of 60 teeth. C. P. B.

1568. *Direct-reading Seismograph.* V. Crémieu. (Comptes Rendus, 156. pp. 882-885, March 10, 1918.)—By employing the principle of a torsion balance of which the suspending wire is bent at its point of insertion, giving an invariable plane of vibration (see Abstract No. 1877 (1918)), a seismograph has been designed by means of which the records may be interpreted directly. Some details of the apparatus are given, suitable for registering all three components of a seismic movement. C. P. B.

1569. *Improvements in Mirror Readings.* J. Ludwig. (Phys. Zeitschr. 14. p. 557, June 15, 1918.)—Below the rotating mirror is arranged a fixed mirror which reflects a vernier adapted to the scale. The mirrors are so disposed that the planes of the images of the scale and vernier are the same, and that the images are in contact along a line. With a telescope the vernier gives the usual increase of accuracy. Without the telescope it compensates for the absence of the latter. E. E. F.

1570. *Standardisation of Hydrometers.* R. T. Glazebrook. (Nature, 91. pp. 412-418, June 19, 1918. From the National Physical Laboratory.)—Three different methods are in use for the standardisation of hydrometers. The instruments are in all cases graduated for use in a liquid at a definite temperature—the standard temperature of the instrument—and give the specific gravity of this liquid at some definite temperature, which may or may not be the standard temperature of the instrument, referred to water at the same or some other temperature. The following cases have arisen.

I. (α) The liquid to be tested must be at the standard temperature of the instrument, say 85° F. (β) The water to which the sp. gr. is referred must also be at this standard temperature, say 85° F.

II. (α) The liquid to be tested must be at the standard temperature of the instrument, say 85° F. (β) The water to which the sp. gr. is referred must be at some other definite temperature, say 60° F. The sp. gr. of the liquid at 85° F. is then referred to that of water at 60° F.

III. (α) The liquid to be tested must be at the standard temperature of the instrument, say 85° F. (β) The graduations are such that they give the value which would be found for the sp. gr. of the liquid if it were cooled or heated to some other temperature and referred to water at that temperature, say 60° F.

A sugar solution which reads 1.1484 by method I (85° F./85° F.), would read 1.447 by method II (85° F./60° F.) and 1.500 by method III (60° F./60° F.).

Method III has the obvious objection that the instrument is correctly graduated only for a liquid having one definite coefficient of expansion, and hence cannot be used without error for others. Method I has been the usual practice at Kew. Method II has the advantage that the reference temperature of the water is fixed and gives results in agreement with the usual definition of specific gravity, which assumes a fixed temperature for the water.

The author invites expressions of opinion concerning these different methods from makers and users of hydrometers. T. H. P.

1571. *Optical Coincidences for Time Transmission.* Schwartz and Villatte. (Comptes Rendus, 156. pp. 121-124, Jan. 18, 1918.)—To facilitate observation of the standard pendulum, arrangements are made to illuminate the field of a small telescope intermittently at each beat. This is placed close to the eyepiece of a larger telescope which is employed for viewing the signals of other observers at a distance, so that all that is necessary is the observation of coincidence of two intermittent illuminations. A variation of the method is to view the distant signals in the telescope, and judge coincidences with the local timekeeper by listening to the beats with a telephone.

C. P. B.

1572. *Azimuth Marks of Cape Transit Circle.* D. Gill. (Observatory, No. 459. pp. 184-185, March, 1918.)—Each azimuth mark is defined by the vertical plane passing through the optical centre of an object-glass placed at the bottom of a pit sunk to the unweathered Malmesbury rock many feet below the surface. At the focal plane of this lens there is a horizontal slide carrying two spider threads, or a spider thread and illuminated aperture. Below the object-glass there is placed a trough of mercury, by means of which it is possible to see the reflected images of the spider threads with a small microscope. These threads are adjusted to be at equal distances from the meridian mark, on opposite sides of the meridian, so that when the image of one of them is superposed on the other it is then certain that the meridian mark is exactly on the meridian line.

C. P. B.

1573. *Longitude Determination by Wireless Telegraphy.* H. Renan. (Comptes Rendus, 156. pp. 758-760, March 10, 1918.)—As intimated in a previous paper [Abstract No. 267 (1912)], the system of exchange of signals by wireless telegraphy has been employed by the observers engaged in deter-

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mining the difference in longitude between Uccle (Belgium) and the Paris Observatory, and a discussion is given showing the comparative accuracy of the new method and the old system of telegraphy. The conclusion is that the mean error is very nearly the same in the two methods, ± 0.0080 sec. for wireless, and ± 0.0071 sec. for ordinary telegraphy. The time of transmission of an ordinary electric signal from Paris to Uccle is found to be 0.008 sec. The final value for the difference of latitude, Paris (Cassini's meridian) and Uccle (meridian circle) is 8m. 5.12s.

C. P. B.

1574. *Influence of Drawing on the Properties of Metallurgical Products.* L. Guillet. (Rev. de Métallurgie, 10. pp. 769-777, June, 1918.)—The author has studied the effect of cold work on the mechanical properties and the resistance of metals and alloys to corrosion. Drawing greatly increases the elastic limit and decreases the resilience. Elongation is diminished to a greater extent than the contraction. Experiments have been made on the resistance of Al and some of its alloys, to corrosion in water and different saline solutions of various strengths. Although in a great many cases the cold-worked product is attacked to a greater degree than the annealed product, this is by no means a general law. The action appears to be a function of the alloy and the acting reagent.

F. C. A. H. L.

1575. *The Elasticity of Ice.* K. R. Koch. (Ann. d. Physik, 41. 4. pp. 709-727, July 17, 1918.)—Nearly 80 years ago the author made numerous determinations of the elastic modulus of ice while on the Labrador coast as a delegate of the German Polar Commission; in spite of good agreement for the same sample, the values for different samples differed appreciably from each other, and, moreover, were greater than those obtained by earlier investigators. The author noticed, however, that in spite of the low temperature prevailing, a considerable decay of the ice-bars took place, which rendered dimensional measurements uncertain. The publication of the results was therefore postponed until further data had been accumulated. Experiments at Freiburg gave a value $E = 646.5$ kg./mm.², while the average value of the Labrador experiments was 696 kg./mm.². The latter experiments were rejected because it was impossible to determine the relation between the elastic force and its direction to the chief crystallographic axis. Hess's results are quoted with comments thereon. The difficulties due to viscosity are emphasised, since very delicate methods are required for measuring small bars, while the condition of the ice is of great importance. Ice from lakes and ponds is traversed by air-bubbles and channels, which are in planes parallel to the frozen surface, the air-channels being lengthways perpendicular to the latter. Figures are given of ice sections cut from Labrador and Bernina ice. When ice which contains air is used, the bubbles and channels act as if the cross-section was reduced and thereby cause the modulus of elasticity to appear too small. Last winter the author took samples from ice lakes on the Bernina Pass, and experiments, details of which are given, were carried out in the coldest room of the Bernina Hospice where a temperature of -8° to -6° C. prevailed. A photograph of the apparatus employed is given in the paper. The dimensional determinations receive adequate description and all the precautions to ensure accuracy are added, an optical method being employed. The use of a microscope with micrometer is not to be recommended, as the observer's presence would occasion temperature fluctuations which could not be determined. The sources of error lie in the difficulties attending the readings, and in the deter-

mination of the permanent deformation due to viscosity. Tables are given, and the sources of error examined and corrected. A general mean value of $E = 625.9 \text{ kg./mm.}^2$ for an average temperature of -7.2°C. was obtained, this being fairly near the author's earlier results. It may perhaps be imagined that the elastic modulus is dependent upon the orientation of the ice with respect to the freezing surface, but the results for rods cut in the same direction differ from rod to rod. The greatest value of the deviation for the same rod reached 1 %, but for different rods over 10 % was recorded. Other explanations must therefore be sought to account for these discrepancies, and the author makes two proposals, viz. that the varying temperatures of night and day have caused internal stresses in the ice, the existence of which was proved by the appearance of cracks after 4-5 days; also that in preparing the rod by filing, etc., the temperature is raised and the possibility given for an alteration in crystalline structure on cooling. The above actions would each account for variation from rod to rod. H. H. Ho.

1576. *Precision Viscosimeter: Relative Viscosities of Water at 0° , 18° , 25° , and 50° .* E. W. Washburn and G. Y. Williams. (Amer. Chem. Soc., Journ. 85. pp. 787-750, June, 1918. Contribution from the Laborat. of Physical Chem. of the Univ. of Illinois, Publication No. 14.)—An improved Ostwald viscosimeter of fused quartz has been designed and is found to possess the following advantages: (1) Its water-constant for a given temperature is not altered by cleaning it with hot liquids or by subjection to wide temperature variations; this magnitude has remained constant to within 0.08 sec. after the instrument has been in use for six months. (2) The water-constant at 25° is 580 secs. and is repeatedly reproducible to about 0.08 sec. under constant conditions. (3) For effective pressures within the limits 180-800 mm. of water, the deviation of the viscosimeter from the requirements of Poiseuille's law is less than 0.08 per cent. (4) An error of as much as 1 c.cm. in the amount of liquid introduced into the viscosimeter changes the time of flow by less than 0.05 per cent. (5) A single instrument can be used for a large temperature-range, since its dimensions do not alter with the temperature. The following values have been obtained for the relative viscosities of water at different temperatures: $\eta_{18}/\eta_0 = 0.58978$, $\pi_{25}/\eta_0 = 0.49741$, $\eta_{50}/\eta_1 = 0.80640$, $\eta_{50}/\eta_{18} = 0.61599$, these numbers being probably accurate to 0.08 per cent. The relative viscosity of a normal potassium chloride solution at 18° is 0.98180. T. H. P.

1577. *Viscosity of Air.* R. A. Millikan. (Ann. d. Physik, 41. 4. pp. 759-766, July 17, 1918.)—A discussion of the most probable value of the viscosity of air, the following conclusions being reached: (1) To within one in a thousand the viscosity of dry air at 28°C. is $\eta_m = 0.00018240$; (2) Between 12° and 80°C. to within one in a thousand, $\eta_t = 0.00018240 - 0.000000498 (28^\circ - t)$. E. H. B.

1578. *Investigation of Molecular Forces by Disturbance of Molecular Equilibrium in Liquid-crystals.* O. Lehmann. (Deutsch. Phys. Gesell., Verh. 15. 10. pp. 418-422, May 30, 1918.)—A discussion is given of the conditions under which the elastic limit might be measured in viscous materials such as marine glue. The author maintains that liquid-crystals have no elasticity as the particles rearrange themselves when the mass is deformed and cannot therefore carry a permanent strain. T. M. L.

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1579. *The "Rutherford" Atom.* G. S. Fulcher. (Science, 88. pp. 274-276, Aug. 22, 1918.)—The paper discusses the theory of Rutherford [Abstracts Nos. 1847 (1911), 1296 (1918)] that an atom has a central concentrated positive nucleus consisting of a number of elementary charges equal to about half the atomic weight. The author considers that for elements of low atomic weight such a simple atom will not explain spectral phenomena. E. M.

1580. *Continuity.* O. Lodge. (Chem. News, 108. pp. 127-186, Sept. 12, and pp. 189-148, Sept. 19, 1918. Presidential Address to the British Assoc. at Birmingham, 1918. Science, 88. pp. 879-895, Sept. 19, and pp. 417-480, Sept. 26, 1918. Nature, 92. pp. 88-48, Sept. 11, 1918.)—The author urges a belief in ultimate continuity as essential to science; regards scientific concentration as an inadequate basis for philosophic generalisation; believes that obscure phenomena may be expressed simply if properly faced; and points out that the non-appearance of anything perfectly uniform and omnipresent is only what should be expected, and is no argument against its real substantial existence. L. H. W.

1581. *Flexure of Telescope Mirror-discs arising from their Weight.* H. S. Jones. (Roy. Soc., Proc. Ser. A. 88. pp. 494-522, July 1, 1918.)—Mathematical.

1582. *Effect of Temperature in Gravity Determinations with v. Sterneck's Apparatus.* C. Mineo. (N. Cimento, 5. Ser. 6. pp. 159-179, March, 1918.)

1583. *Einstein's Stationary Gravitation Field.* P. Ehrenfest. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1187-1191, May 80, 1918.)—Discusses the hypothesis of equivalence on which Einstein bases his attempt at a theory of gravitation, and which requires a curvature of the rays of light in a field of attraction. The problem is put thus. Let a laboratory L with the observers in it have some accelerated motion with regard to a system of co-ordinates x, y, z , which is not accelerated. Let it, for example, move parallel to the z -axis with some positive acceleration. Then the observers will find that all the inert masses which are at rest with regard to the laboratory exert a pressure on the bodies which are in contact with their bottom side. There are two ways for these observers to explain this pressure: (1) Our laboratory has an acceleration upwards, hence all inert masses press on the bodies under them; (2) our laboratory is at rest, but a field of force acts in it which pulls the masses down. Observations on the course of the rays of light seem to make it possible to decide between the ways (1) and (2), for with regard to the system of co-ordinates x, y, z , the light travels rectilinearly, but with regard to the accelerated laboratory *curvilinearly*.

The author reaches the conclusion that all statical fields of attraction, except those of a very particular class, are in contradiction with Einstein's hypothesis of equivalence. For example, the statical field due to several centres of attraction which are stationary with respect to each other, is not compatible with the hypothesis of equivalence. E. H. B.

1584. *Three Ice Storms.* C. F. Brooks. (Science, 88. pp. 198-194, Aug. 8, 1918.)—Two of the ice storms here discussed were observed at Blue Hill in Feb., 1918. In the case of the first a south wind was blowing during the afternoon of the 16th, and this was gradually forced upwards by a cold north-east wind which crept in below it. Rain fell during the night from
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the upper south wind, and, freezing on trees and other objects in the cold lower current, formed the "ice storm." The second example was of the same type, but in this case the ice attained to a greater thickness (1 in.). In the third example a larger area was under observation. The precipitation underwent a gradual change from deep snow in the north of the observed belt to a thick covering of frozen rain, sufficient to break down small trees, in the south. Ten miles still further south there was no ice or snow.

J. S. DI.

1585. *Correction of Actinometer Measurements for Aqueous Depletion.* F. W. Very. (Science, 87. pp. 639-640, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—Tables are given for the approximate correction of actinometric observations with air masses and pressures of aqueous vapour as arguments. More data are required, including simultaneous observations of the distribution of aqueous vapour in the upper air by means of sounding balloon ascensions or high kite flights.

C. P. B.

1586. *Volcanic Dust and other Factors in the Production of Climatic Changes, and their possible Relation to Ice Ages.* W. J. Humphreys. (Frank. Inst., Journ. 176. pp. 181-172, Aug., 1918. Mount Weather Observatory, Bull. 6. pp. 1-84, 1918.)—In this paper the author develops the view that the ice ages of the past may have been brought about by increased volcanic activity with a consequent increase in the amount of fine dust in the upper layers of the atmosphere. Theoretical reasoning is brought forward to show that such dust by its scattering and reflecting of radiation might produce a considerable decrease of temperature on the earth's surface. Turning to observational data the author finds that considerable decreases in pyrheliometric readings have followed all the larger volcanic eruptions since reliable records have been kept. The observations suggest that a decrease of 10 % in the total incident radiation at the earth's surface may occur for a time after unusual volcanic activity, and such a falling off as this, if continued for a sufficient period, would cause a decrease of temperature at the surface of the earth of over 6° C. The mean yearly temperature of the earth over the period 1872-1912 is compared with the mean pyrheliometric readings (P), and also with the sun-spot numbers (S), and it is found that by a suitable combination of P with S excellent agreement can be obtained between the combined P and S curve and the temperature curve. A further effect of dust in the earth's atmosphere on temperature would be produced by the radiation from the dust particles to the earth, but the increase of temperature arising from this source is found to be unimportant. It is therefore surmised that continued volcanic activity might, through the dust introduced into the upper layers of the atmosphere, cause a considerable decrease in temperature, and that herein may be found an explanation of the ice ages of the past.

J. S. DI.

1587. *Atmospheric Humidity as related to Haze, Fog, and Visibility at Blue Hill.* A. H. Palmer. (Mount Weather Observatory, Bull. 5. Part 4. pp. 281-246, 1918.)

1588. *Determination of the Azimuth and Apparent Emergence Angle of Longitudinal Earthquake Waves.* H. Benndorf. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 169-188, Jan., 1918.)—Galitzin's method is first referred to, in which he calculated formulæ for determining the azimuth and apparent emergence angle of longitudinal earth waves from the readings of three seis-

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mographs having electrical recorders, no limiting assumptions being made as to the nature of the earth surface movement. The formulæ held good, however, only under the following conditions, viz., all three seismographs as well as the three galvanometers must show exactly the same periodic limits, and all six instruments must have equal vibration periods by suitable damping. Since there are few stations possessing Galitzin's instruments, and as it is of great theoretical interest to obtain abundant data for emergence-angle determinations, the author has investigated how the emergence angle may be determined by the ordinary seismographs. Although theoretical determinations at least can be made from seismograph records when the pendulum constants are known, this method is extraordinarily troublesome and protracted. The author has therefore made a series of investigations to explain certain seismographic problems, giving a mathematical exposition with tables of calculations. Simple formulæ are established for the azimuth and emergence angle, which are of practical importance, since it is exceedingly difficult to obtain three seismographs with the same vibration periods and equal damping constants.

H. H. HO.

1589. *Temperature in Deep Wells at Findlay, Ohio.* J. Johnston. (Amer. Journ. Sci. 86. pp. 181-184, Aug., 1918.)—The paper contains the results of a series of measurements made at the instance of the United States Geological Survey. The temperatures were found by maximum thermometers previously calibrated at the Bureau of Standards and found not to be in error by more than 0.1 deg. C., which is the limit of their practical accuracy. If only a single thermometer be used, accidental jarring while being raised to the surface might lead to errors the existence of which might not be detected, so to eliminate this possibility of error three thermometers were always used together. The thermometers were enclosed in a special kind of cage exact details of which are given, together with all precautions for eliminating errors due to the apparatus. Temperatures at the bottom of a hole should not be taken until at least 24 hours have elapsed since drilling was discontinued or since water was poured into the hole. The most serious disturbing factor in the attempted determination of the temperature of the rock (as distinct from that of the air or gas in the hole) is the flow of gas, which in expanding cools itself off. This latter influence is evident in the author's measurements, which do not represent the temperatures of the rock at horizons above that of the gas in flow. A table of results is given. The temperature gradient in the sedimentary rocks from the "Trenton" limestone downward is about 0.41 deg. C. (0.74 deg. F.) per 100 feet, while that in the crystalline rocks appears to be somewhat higher, although the data were very insufficient for drawing any very certain conclusions.

H. H. HO.

1590. *Viscosity of Glacier Ice.* R. M. Deeley and P. H. Parr. (Phil. Mag. 26. pp. 85-111, July, 1918.)—At the outset the authors remark that the question of the flow of glaciers considered as viscous fluid masses has already been dealt with by several investigators, but the absence of reliable data concerning thickness and surface slope has rendered impossible any exact mathematical analysis of their movement. The paper contains an historical survey of the whole subject. The authors point out that it would be a distinct advantage to have a name for the unit of viscosity, and suggest the word "Poise" (after Poiseuille). As compared with the mass of a glacier, the ice granules of which it consists are small and may even more nearly be compared with the molecules of a small volume of such a liquid as oil. Therefore,

even though the viscosity of a glacier cannot be considered as quite the same thing as the viscosity of water and other mobile liquids, yet for all practical purposes glacier ice may be regarded as a perfect liquid of high viscosity and will flow until all the stresses are in hydrostatic equilibrium. Although the experiments by McConnell and Kidd in 1888 were carried out with skill and accuracy, they have not hitherto been mathematically examined, and the authors, taking the mean results from the experiments, obtain a viscosity of 24.8×10^{13} poises. Since the yield must have been at right angles to the optic axes, the high viscosity may be partly due to the low temperature (about -5° C.), to the fact that the bar consisted of a large number of crystalline columns, and that the shear planes were inclined to the direction of the stress. Blümcke and Hess observed the ice velocity of the Hintereis Glacier along a number of lines drawn across the glacier, the rate of ablation and the altitude of its various parts, and by the help of borings they attempted, with certain hypothetical considerations, to construct sections of the glacier showing its width and depth at certain positions. The main objection to their method is that they assume, in the first place, that the velocity is the same in all vertical lines, which would make the glacier too shallow since the glacier slips bodily and also flows differentially. The velocity also at any point on the surface does not depend entirely on the ice thickness at that place, but is affected by the depth of the ice at all points of the section, and, to a certain extent, on the shape of the under surface of the glacier above and below the section. However, the sections are the most accurate yet obtained. The authors propose to discuss the data furnished by Blümcke and Hess, with a view to calculating the viscosity of the Hintereis Glacier. The conditions of flow of viscous fluids are only known for certain shaped channels such as along semicircular or elliptic channels, or channels of width great as compared with depth. In the case of the Hintereis Glacier the stream is somewhat deep as compared with the width, and the form of section departs markedly from that of an ellipse. Weinberg's method was to find an ellipse which is the equivalent of the glacier-bed. Changes occur from time to time in the velocity of glacier flow, these being intimately connected with their varying advances and retreats resulting from periodical alterations in the amounts of precipitation, ablation, or other causes. During retreats of the glacier snout the velocity and thickness decrease, whilst during its advance they increase. The velocity corresponding to the steady state occurs at some time between a period of maximum and minimum velocity, and our knowledge of the seasonal variations of glacier flow is by no means complete. Great interest attaches to the winter velocity where the conditions are more equable than in summer. The amount of slip between ice and rock-bed is a most important but difficult value to ascertain, and only approximations can be given. The resistance offered to the flow of a glacier is of two kinds, viz. the frictional resistance of the floor, and the resistance offered by the ice to change of shape. Very little is known concerning the coefficient of friction of glaciers upon their beds, while it is not clear why a glacier slips at all considering the slight slope. Calculations give 52.2 % as the probable slip at the middle and 68.7 % at the sides. Other values of the slip are discussed by the authors from different sets of observations. The force producing motion results from the slope of the glacier, which can only be obtained by empirical methods; the downward component of gravity, however, is assumed as being proportional to the slope of the upper surface of the glacier, since the difference between the slope of the upper surface and that of the glacier-bed cannot differ very much. The viscosity of glacier ice is then calculated, and while Weinberg

obtained his result by fitting to the section of the glacier a semi-ellipse which he regarded as its equivalent, the present authors give a method by which the ellipse may be accurately fitted to the channel. A form of curve is also described and used for calculating the viscosity, which resembles that of a glaciated valley section much more closely than does an ellipse. Generally speaking, the form of a well-glaciated valley very closely approximates to a parabola, but the conditions of viscosity flow have not yet been ascertained for a parabolic channel. The value for the viscosity is given at 125×10^{19} poises, a table of results by other authors being added. The great defect of the ellipse as a basis for comparison lies in the fact that the boundary is vertical at the sides (for the solution has only been found for the complete semi-ellipse), whilst the sides of a natural valley are sloping. The chief reasons for the figures obtained being so much greater than those of Weinberg are: that the velocity is much less, more slip is allowed, the ice-slope is steeper, and the viscosity is the winter-value when the glacier is probably in an equally dry condition from top to bottom. Numerous curves and tables are given.

H. H. Ho.

1591. *Microseismic Oscillations and Surface Waves*. C. Mainka. (Phys. Zeitschr. 14. pp. 555-557, June 15, 1918.)—At Irkutsk, the amplitude of the horizontal microseismic oscillations is 0.5μ at the most, and the most usual period is 5 secs. The amplitudes at Pulkowa, Graz, and Göttingen are somewhat larger, but smaller than those at Strassburg. The periods tend to be shorter in summer than in winter, when 9-sec. periods are sometimes found. Some connection is indicated with sea-waves, but not with the direction of the wind. The chief plane of oscillation is east and west. The mean ratio of horizontal to vertical amplitude is 1.1, but more data are required. [Errata, ibid. p. 728, Aug. 1, 1918.]

E. E. F.

1592. *Colours of the Atmosphere*. A. Heim. (Archives des Sciences, 85. pp. 178-188, Feb., 1918.)—Discussing the varying colours presented by atmospheric glare, dependent largely on the intensity and direction of the incident light on the particles, attention is drawn to the appearances at different altitudes and to the question of how estimation of distances is affected by these mist or dust colours. The varying tints and structure of the rays often seen projected through the atmosphere when the sun is hidden by clouds or hills are also described; these features are especially prominent during stormy weather, when the proportion of water-vapour in the atmosphere is relatively high. The phenomena observed at sunrise and sunset are examined in some detail. Illumination of the higher atmosphere, diffuse reflection, and diffraction, are all called in to explain the effects recorded.

C. P. B.

1593. *Conditions of Equilibrium of the Solar Atmosphere with respect to the Repulsive Force of Radiation*. G. Gouy. (Comptes Rendus, 157. pp. 186-191, July 21, 1918.)—The author points out the long-established fact that exterior layers of the sun are much more extended than gravity or Mariotte's law demands. For example, a difference of level of 82 km. for hydrogen at 8000° absolute should alter the pressure by half, and therefore a difference of 5000 km. would give for the pressure ratio a number approaching $(\frac{1}{2})^{160} = 10^{-47}$. A layer of hydrogen which has a pressure of 1 atmo. at the surface of the photosphere should therefore have a density practically nil at 5000 km. distance. At the latter point, however, the spectrum of hydrogen is always shown with intensity. Accordingly the author has examined the

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influence which radiation-pressure may exercise on gases and solar vapours. This radiation-pressure has often been considered as the cause of the corona dust. Its existence for absorbing gases has been established by Lebedew's experiments, which determined that the force exercised upon the gas is the same as that upon a dark body for an equal amount of radiant energy absorbed. The author then gives an elementary mathematical demonstration of this result, different cases and assumptions being exhaustively discussed. It follows from the investigation that the repulsion exercised by radiation upon the metallic vapours of the sun should be taken into consideration, although a definite value cannot be assigned to it in the absence of data. This repulsion is important for spectrum analysis, since it is opposed to the weight. It is therefore natural that sodium, which at very elevated temperatures possesses this property to a high degree, is to be found at an exceptional height in the solar atmosphere. Metallic vapours, in general, produce absorption rays without special conditions, but the majority of gases proper (such as hydrogen, helium, etc.) must be rendered active by electrical action before absorption is sensible, so that the gaseous molecules will exert repulsion on each other. If the electrical conditions, which render a gas active, cease to exist above a certain height, the repulsion will also cease. It is therefore not impossible that a gas will accumulate by this mechanism in the exterior solar zones without escaping, and this perhaps explains the anomalous helium spectrum, since the density is then supposed a maximum at a certain height.

H. H. Ho.

1594. *Diminution of Solar Radiation during 1912.* D. Eginitis. (Comptes Rendus, 156. pp. 855-857, March 17, 1913.)—Quoting an observation of Wolf at Heidelberg (Ast. Nachr. No. 4587), that towards the end of June, 1912, a greyish-white veil appeared to cover the sky, accompanied by a series of vivid twilight colours, producing a brownish tint over the sun and moon, and reducing the light of stars by two magnitudes, a discussion is given of the heliographic records made at Athens during the period in question. Systematic variations of the traces are described, which appear to have been closely accordant in time with the other phenomena.

C. P. B.

1595. *Physical Interpretation of Corona Spectrum.* J. W. Nicholson. (Observatory, No. 458. pp. 108-112, Feb., 1913.)—A discussion is given of the application of recently developed physical theories to several outstanding astronomical problems, chiefly in relation to the spectra of nebulae and the solar corona. In the case of the corona spectrum, it is found that the pairs of lines corresponding to a charged nucleus with five times the charge of an electron, surrounded by 8, 4, or 5 electrons, are all represented by corresponding ratios of known coronal spectrum lines. This nucleus has 5 electrons when it is electrically neutral. Attention is drawn to the important theory developed by Planck, in which the radiation from an energised system is emitted discontinuously; resulting from this the spectrum under consideration should contain a series of lines, such that the cube-roots of their wave-lengths are in arithmetical progression. This condition is satisfied by the lines $\lambda\lambda 5078, 4725, 4400, 4087, \text{---}, 3505$, within experimental limits of error.

C. P. B.

1596. *Solar Rotation in 1911.* J. S. Plaskett and R. E. De Lury. (Astrophys. Journ. 87. pp. 78-104, March, 1913.)—The region of spectrum allotted to the Dominion Observatory, Ottawa, Canada, for investigations of the solar rotation is in the yellow-green, $\lambda\lambda 5500\text{--}\lambda 5700$. This subdivision of the

work was arranged at the Solar Union Conference at Mount Wilson in 1910, while for general comparison a region common to all observers was that from $\lambda 4220$ to $\lambda 4280$. Fifteen to twenty lines are measured in the special region, selected so as to include as many elements as possible, especially those of high or low atomic weight; about ten lines are examined in the special region. The spectroscopic equipment comprised a 20-in. coelostat, with secondary mirror, giving a horizontal beam north and south to a concave mirror, 18 in. diam. and 80 ft. focus. The spectrograph is of the Littrow form, having a combined collimator and camera objective of 6 in. aperture and 28 ft. focal length. A long discussion is given of the differences of measurement by different observers, the conclusion being that it is at present impossible to discriminate between small personal errors and differences due to a real variation of the solar rotation. The velocity formula determined from Plaskett's measurements is—

$$V = (1.488 + 0.532 \cos^2 \phi) \cos \phi; \xi = 10.82^\circ + 4.06^\circ \cos^2 \phi,$$

with an uncertainty of from 2 to 8 %. No systematic difference of velocity for different elements is present in the Ottawa measurements. C. P. B.

1597. *Refraction by Solar Atmosphere.* R. S. Capon. (Roy. Astronom. Soc., M.N. 78. pp. 861–869, March, 1918.)—From an analysis of the motions of sun-spots it is suggested that there appears to be evidence of their position being influenced by their position on the sun's disc with respect to the earth, and the effect is ascribed to refraction in the solar atmosphere. From the Greenwich photoheliograph measures the heliographic latitudes of spots at longitudes 60° east and west of the central meridian were tabulated, and the mean of the two values compared with the latitude of the spot as it passed the central meridian. From a table of the differences it appears that as a spot crosses the sun's disc it moves towards the pole of the hemisphere in which it is situated, until it reaches the central meridian, when the motion is reversed, and for the remainder of its path it moves away from the pole, and this effect becomes more marked as the latitude increases. Evidence is also found for an apparent decrease of angular velocity as the longitude distance from the central meridian increases. C. P. B.

1598. *Measurements of Solar Radiation.* C. G. Abbot. (Astrophys. Journ. 87. pp. 180–144, March, 1918.)—Criticism of the author's measurements of solar radiation has been made by F. W. Very [Abstract No. 988 (1918)]. This the author now takes in detail and seeks to show its fallacy. One of the critic's points was that the Smithsonian method would be sound if the atmosphere remained of uniform transparency during the period of observation and if the bolometer could measure homogeneous rays, and these conditions are claimed to exist. C. P. B.

1599. *Circulation in Solar Atmosphere.* F. Slocum. (Science, 87. p. 642, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America. Astrophys. Journ. 87. pp. 854–858, June, 1918.)—Based on a study of 4600 solar prominences which by their form or movement indicate a horizontal circulation in the solar atmosphere, a series of results were given, classified into groups according to direction, latitude, and height above chromosphere. Only the north-south components of the movements are measured at present from the spectro-heliograms, but it may be possible later to apply the east-west components from radial velocity determinations. C. P. B.

1600. *Types of Prominences Associated with Sun-spots.* [Mrs.] M. A. Evershed. (Roy. Astronom. Soc., M.N. 78. pp. 422-480, April, 1918.)—Referring to the photographs published by Slocum [Abstract No. 868 (1918)], which show distinct evidence of the flow of prominence matter towards the centre of a large spot then on the solar limb, the difficulty of identifying any particular feature on successive plates is mentioned, and as wherever any certain evidence of motion has been detected, it has generally been outwards, the single instance quoted cannot be taken as typical of the attraction of sun-spots for prominences. A series of photographs are reproduced showing various types of prominence action, and from a close study of these it is concluded that the motions of prominences situated directly above sun-spot groups are of quite a different nature to those in the penumbra of spots. The gases rise from the centre with velocities about 12 km. per sec., and some distance away this diminishes to 2-8 km. per sec. The outward-moving gas seems to have a tendency to fall back upon the chromosphere. C. P. B.

1601. *Frequency of Prominences on East and West Solar Limbs.* J. Evershed. (Kodaikanal Observatory, Bull. No. 28. Nature, 91. p. 281, May 15, 1918. Abstract.)—Resulting from an extensive inquiry there appears to be abundant evidence of a distinct predominance of prominences at the eastern limb of the sun, with suggestions of an annual periodicity of the effect, having maxima in Jan. and Aug. and minima in April and Nov. Metallic prominences, and those showing displacement of the hydrogen lines show a still greater difference than the quiet prominences. C. P. B.

1602. *Sun's Polar and Equatorial Diameters.* R. P. S. Chevalier. (Ann. de l'Observatoire Astronomique de Zô-sè (China) 6. Nature, 91. p. 225, May 1, 1918. Abstract.)—From a series of photographic records covering the period 1905-1910 it is found that the sun's polar diam. is greater than the equatorial one, the difference appearing to be variable. The mean difference is given as $+0.19''$. C. P. B.

1603. *Substitute for Bode's Law.* [Miss] M. A. Blagg. (Roy. Astronom. Soc., M.N. 78. pp. 414-422, April, 1918.)—Starting with the original idea of a geometrical series, tables are constructed showing the analysis of the log-differences corresponding to the distances of the planets in the solar system, the satellite systems of Jupiter and Saturn, and a remarkable similarity is found between the "variation of distance" curve in all three systems. The curve of variation is illustrated, and it is significant that the places for the minor planets and Saturn's rings are almost exactly the two positions of max. slope on the curve. One of the physical conclusions affecting the problem is that if the distances of the planets and satellites obey with tolerable fidelity a regular law which has the same features for systems so different as those of the sun and Jupiter, this law probably applies to the original distances and not to the distances as modified by tidal action or mutual perturbation. This view accords very closely with the opinion expressed in 1881 by G. Darwin from quite different considerations. C. P. B.

1604. *Visual Search for Minor Planets.* J. Lagrula. (Comptes Rendus, 156. pp. 1184-1186, April 14, 1918.)—The principal difficulty attending the search for new minor planets is owing to their being so nearly like stars of about the same magnitude; when their relative motion is sufficiently rapid, this constitutes the most reliable method of distinguishing them: by employ-
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ing the simple device of a binocular eyepiece, one showing the ordinary image of the star field while the other is arranged to give a view of a positive copy of the star region under examination. This is illuminated by coloured light, so that when lightly displaced one would see a group of stars, with a similar group of coloured stars, each in similar position to its respective real object. Then if the coloured images are accurately superposed on the real star-images, it becomes a simple matter to examine the field of view rapidly for any points of white light still remaining, when there may be either new objects or planets whose movement might soon be investigated.

C. P. B.

1605. Total Solar Radiation during Annular Eclipse. W. H. Julius. (*Astrophys. Journ.* 87. pp. 225-288, May, 1918. *Konink. Akad. Wetensch. Amsterdam, Proc.* 15. pp. 1451-1468, July 15, 1918.)—During the annular eclipse of the sun on April 17, 1912, the variation of the total solar radiation was observed near Maastricht under favourable sky conditions, with two mutually independent sets of apparatus. One set, comprising a bolometer and a short-period recording galvanometer, was employed in finding the proportion of the minimum to the maximum radiation. This ratio was found to be nearly 1 : 5000. On this was based an estimate of the total amount of energy radiated and scattered by the entire solar atmosphere, giving about 1 : 1000. It would appear impossible, therefore, to ascribe the fall of the sun's brightness towards the limb of the disc to absorption or scattering of the light by an atmosphere enveloping a body that would otherwise appear uniformly luminous. With the other set of apparatus, consisting of a thermopile and accessories, a sufficient number of readings were obtained for constructing the whole radiation curve from the first until the fourth contact.

C. P. B.

1606. Variation of Solar Radiation. C. G. Abbot, F. E. Fowle, and L. B. Aldrich. (*Astronom. Nachr.*, No. 4656. *Nature*, 91. p. 881, June 12, 1918. Abstract. *Washington Acad. Sci., Journ.* 8. pp. 809-815, June 4, 1918. *Meteorolog. Zeitschr.* 80. pp. 257-261, June, 1918.)—About 700 observations have now been secured by the Smithsonian observers at altitudes varying from sea-level to 4420 m. A preliminary discussion of these leads to the following conclusions :—(1) The mean value of the solar constant of radiation for the epoch 1905-12 is 1.929 cal. per sq. cm. per min. (2) An increase of 0.07 cal. per sq. cm. per min. accompanies an increase of 100 sun-spot numbers (Wolfer). (3) An irregular variation frequently ranging for more than 0.07 cal. per sq. cm. per min. within an interval of 10 days appears to be established from nearly simultaneous measurements at Mount Wilson in California, and Bassour in Algeria.

C. P. B.

1607. Enhanced Lines in Early Spectrum of Nova Geminorum (1912). H. F. Newall and F. J. M. Stratton. (*Roy. Astronom. Soc., M.N.* 78. pp. 880-882, March, 1918.)—From detailed comparisons of the spectrum of Nova Geminorum (No. 2) obtained at Cambridge in March and April, 1912, with the spectrum of α Cygni a close resemblance has been noted between the early absorption spectrum of the Nova (1912, March 15) and the α Cygni spectrum. The agreement is of the same order as that found by the Kensington observers for the bright-line spectrum of Nova Persei. The identification has been made on the assumption that the strong absorption lines of the Nova are all displaced towards the violet. Of the 65 lines of

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intensity 2 or more given by Miss Maury for α Cygni between $H\beta$ and $\lambda 4068$, 50 are well identified in the Nova absorption spectrum. This is well shown on a reproduction of the two spectra placed side by side. From a study of the comparative intensities of the lines, it appears that the Nova spectrum is intermediate in type between α Cygni and γ Cygni. The elements represented by their enhanced spark lines are titanium and iron certainly; also most probably vanadium, scandium, and strontium; chromium and zirconium somewhat doubtful.

C. P. B.

1608. *Spectrum of Nova Geminorum* (1912). F. C. Jordan. (Allegheny Observatory, Univ. of Pittsburgh, Publ. 8. No. 8. Nature, 91. p. 252, May 8, 1913. Abstract.)—Description of 18 spectrograms of Nova Geminorum (1912), with wave-length tables and intensity curves. From measurements of the H and K absorption lines, the weighted means of the deduced velocities yield a curve which follows to some extent the light-variations of the Nova, the velocities being positive when the star is brighter and negative when it is fainter.

C. P. B.

1609. *Parallax of Nova Geminorum* (1912). F. Slocum. (Roy. Astronom. Soc., M.N. 78. pp. 487–440, April, 1913.)—Observations for parallax were made from fifteen plates exposed during the period 1912, March 18–1913 March 9. Two exposures were made on each plate, varying from 6 to 15 mins., according to the transparency of the atmosphere, etc. The resulting value of the parallax is $+0.011''$, corresponding to a distance of 296 light-years.

C. P. B.

1610. *Spectrum of Nova Geminorum* (1912). F. Küstner. (Astronom. Nachr. No. 4654. Nature, 91. p. 857, June 5, 1913. Abstract.)—An analysis of 241 lines in the spectrum of Nova Geminorum (1912) results in the suggested presence of lines of uranium, titanium, and blue argon. Radium, manganese, and zirconium may be present, but no evidence is found for emanation, iron, or vanadium. Calcium and helium are also accepted as present, and magnesium doubtfully.

C. P. B.

1611. *Distribution of Bright Stars in Space*. A. S. Eddington. (Roy. Astronom. Soc., M.N. 78. pp. 846–858, March, 1913.)—Dealing with stars brighter than 5.8 magnitude, and examining those of spectral type A and K separately, the proper motions have been investigated for two regions, one typical of high galactic latitudes, and the other of low. The method has been most successful with the K type stars. With these the numbers appear to accord well with the usually accepted views of stellar distribution. It is supposed that near the sun the actual density of the stars is fairly uniform; that in the plane of the Galaxy this uniform distribution extends a great distance, whilst in directions perpendicular to this plane the density begins to thin out rather rapidly. From the figures given it appears that there is little difference in the two directions until a parallax of $0.01''$ is reached; after that the decrease of density in the high latitude becomes more and more noticeable, so that at a parallax $0.004''$ it is not more than a third of the density in the galactic planes.

C. P. B.

1612. *Northern Durchmusterung*. E. C. Pickering. (Science, 87. pp. 640–641, April 25, 1913. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—One of the greatest needs of astronomy at the present time is the extension of the work of the Cape Photographic Durch-

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masterung to the North Pole. A plan has been prepared for taking the necessary photographs at Harvard, with the 16-in. Metcalf telescope, using curved plates. The photometric and photographic magnitudes, on a uniform scale, will be determined for a number of standard stars on each plate, and the whole then sent to Kapteyn for measurement and reduction. If completed, the catalogue will contain 800,000 stars or more. C. P. B.

1613. *Distribution of Carrington's Circumpolar Stars.* F. W. Dyson. (Roy. Astronom. Soc., M.N. 78. pp. 884-845, March, 1918.)—An attempt is made to investigate the law of distribution of stars in space according to distance, by comparisons of the observed angular velocities or proper motions with the probable law of distribution of the linear velocities. The resulting values are tabulated, and also plotted as a curve showing numbers of stars at various distances indicated by their respective parallaxes. The most important feature shown by this is the comparatively close limits of parallax within which most of the stars lie; 70 % having parallaxes between $0.005''$ and $0.0015''$. A determination is also made of the distribution of absolute luminosities; that is, the number of stars of given luminosity as compared with the sun, in unit spaces. C. P. B.

1614. *Provisional Orbits of Y Piscium and RR Draconis.* H. Shapley. (Astrophys. Journ. 87. pp. 154-168, April, 1918.)—A large majority of the eclipsing binaries whose light decreases more than one magnitude at principal minimum are composed of bright primary stars with larger faint companions. The determination of the secondary spectra is of importance in assigning the relative masses, but in many cases the duration of the minimum phase is too short to permit the making of a spectrogram. Details are given of an attempt to utilise the colour index method by observing the difference between the visual and photographic ranges. [See also Abstracts Nos. 880, 947 (1918).] Evidence is given for regarding the darker components of eclipsing systems as much less dense than their bright companions, and therefore probably they are younger bodies. C. P. B.

1615. *Galactic Motions of Bright Stars.* H. C. Plummer. (Roy. Astronom. Soc., M.N. 78. pp. 450-470, April, 1918.)—In continuation of former papers [Abstract No. 785 (1918)] the radial velocities of the bright stars of Type A are discussed in relation to their projected components on the plane of the Milky Way. The results are also summarised in the form of *hodograms*, representing the velocities of the stars at a given epoch. C. P. B.

1616. *Scale of the "Yerkes" Actinometry.* J. A. Parkhurst. (Science, 87. p. 641, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—A new determination of the absolute scale for photographic magnitudes indicates that the published scale may be extended by about 6%. The application of this correction brings the magnitudes into better agreement with the Harvard values. C. P. B.

1617. *Photographic Chart of Milky Way.* C. Easton. (Astrophys. Journ. 87. pp. 105-118, March, 1918.)—Drawings have been made from the available photographs of the Milky Way, and combined into one chart on a spherical projection so as to indicate the general aspect of the whole galactic structure. The discussion of the form is based on the spiral-structure theory, and a hypothetical spiral is centred on the drawing for illustrating the points considered. There appears to be no evidence of the existence of *continuous* VOL. XVI.—A.—1918.

masses of opaque matter lying between the earth and the stars. Comparison of the types of convolutions found in the Galaxy with those of well-known spiral nebulae suggests that our sidereal system is in an advanced stage of development, approaching rather to the type of M 101 than to that of M 51.

C. P. B.

1618. *Real Brightness of Variable Stars*. **H. N. Russell**. (Science, 87. pp. 651-652, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—The number of variables and of stars having peculiar spectra contained in Boss's Preliminary General Catalogue is large enough to enable an approximate estimate of their mean distance and real brightness to be made by the method of parallaxic motion. Tables are given showing the computed values for six groups of variables.

C. P. B.

1619. *Algol-variable RR Draconis*. **F. H. Seares**. (Astrophys. Journ. 87. pp. 204-221, April, 1918. Contribution from the Mount Wilson Solar Observatory, No. 68.)—Comparison of photographic results for this star [Abstract No. 576 (1918)] with the incomplete visual light-curve indicated that the photographic variation is greater than the visual. A further examination of the relative dimensions and light-intensities of the two objects composing the system made it practically certain that the difference must be real, and this has been confirmed by photographs taken during the minimum of Sept. 10, 1912, made alternately on ordinary and isochromatic plates, the latter being used with a yellow filter. The total number of exposures was 81, covering the minimum and parts of both branches of the curve, extending over an interval of 5h. 27m. Examination of the variation of colour index shows that the darker component of the system is redder than the brighter component by an amount corresponding to 1.8 times the interval separating successive spectral classes.

C. P. B.

1620. *Eclipsing Binary ϵ Aurigæ*. **H. Shapley**. (Science, 87. pp. 646-647, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—A study of the light curve of ϵ Aurigæ, period 27.1 years, leads to the conclusion that it is an eclipsing binary. The eclipse is total, the small bright star being hidden for more than a year behind the faint companion.

C. P. B.

1621. *Rate of Light-changes in Various Celestial Objects*. **S. I. Bailey**. (Science, 87. pp. 644-645, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—The cluster M8 shows some remarkable examples of variable stars with great rates of increase of light. On a photograph taken with the 18-in. Boyden refractor about 1200 stars are shown, 900 of which were examined for variability, resulting in the detection of 187 objects showing changes. Among these variables the max. rate of increase appears to be more than 6 magnitudes an hour. The mean rate of increase is about $2\frac{1}{2}$ magnitudes an hour.

C. P. B.

1622. *Spectrum of R Lyræ*. **S. Albrecht**. (Science, 87. p. 641, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—From a study of two series of three-prism spectrograms of R Lyræ taken at the Lick Observatory, it is concluded that the radial velocity is -27.22 km. per sec., and that it is constant or nearly so. The spectrum is indexed as somewhat later than type Md.

C. P. B.

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1623. *Spectroscopic Binary*. BD — 1° 948. **Z. Daniel**. (Astronom. Nachr. No. 4688. Nature, 91. p. 122, April 8, 1918. Abstract.)—This star shows the same peculiarity with regard to the K line of calcium that is exhibited by δ Orionis, in that this line does not indicate motion in the line of sight. The Harvard magnitude is 5.87, and spectrum type B2, and it is interesting to note that this star is less than a degree from δ Orionis. C. P. B.

1624. *Stellar Radial Velocities*. **W. S. Adams**. (Science, 87. pp. 648-644, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—Spectroscopic notes are given of results obtained in the course of regular radial-velocity work with the 60-in. reflector at Mount Wilson. Two photographs of the spectrum of Lalande 15290, Mag. 8.2 G type, are interesting in that they show that its radial velocity is the largest of any star observed to date in the northern sky, varying from -241 to -250 km. Observations of a number of the brighter stars in the λ and χ Persei clusters lead to the conclusion that most of these stars have nearly the same radial velocity and apparently are moving together. In Nov. the radial velocity of Nova Geminorum (1912) was found to be about +5 km. per sec. C. P. B.

1625. *Radial Velocity of a Coronæ Borealis*. **K. Schwarzschild**. (Astronom. Nachr. No. 4646. Nature, 91. p. 253, May 8, 1918. Abstract.)—Description of experiments in determination of radial velocities by Wood's method of interposing an absorbing cell of neodymium chloride near the photographic plate, of an objective-prism spectrograph. Probable error about ± 5.7 km. per sec. A period of 17.86 days is indicated. C. P. B.

1626. *Radial Velocity of 68 Tauri*. **K. Schwarzschild**. (Preuss. Akad. Wiss. Berlin, Ber. 16. pp. 806-807, 1918.)—Experiments are described having for their object the determination of radial velocities with objective-prism spectrograms, and details are given of measurements made on spectra of the star 68 Tauri. C. P. B.

1627. *Radial Velocity of a Persei*. **J. H. Pitman**. (Lick Observatory, Bull. 224. Nature, 91. p. 121, April 8, 1918. Abstract.)—From a discussion of the available data for the elements of this star the author concludes that the radial velocity is either constant or only minutely variable. C. P. B.

1628. *Reversals of Calcium Lines in Stellar Spectra*. **G. Eberhard and K. Schwarzschild**. (Preuss. Akad. Wiss. Berlin, Ber. 16. pp. 808-810, 1918.)—Discussion of the occurrence of fine reversals in the H and K lines of calcium on photographs of the spectra of certain stars. C. P. B.

1629. *Spectra of Gaseous Nebulae*. **A. J. Cannon**. (Science, 87. pp. 642-643, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—Examination of the spectra of 140 gaseous nebulae results in their being divided into three sub-classes. The principal of these may be represented by N. G. C. 7662, having nebular lines strong, 8726, 8729 very faint, and 8869, 4686 well marked. A second class has the strongest line in the violet at 8727, possibly a blend of 8726, 8729, while the chief nebular lines are feeble. D.M. -12° 1172 is the typical object of this division. A third division has 4686 for its strongest line, N.G.C. 60 being typical. This class is of special interest owing to a possible connection with the spectra of class O. C. P. B.

1630. *Path of the Great Detonating Meteor of September 28, 1910.* G. v. Niessl. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1888-1986, Nov., 1912.)

1631. *Fireballs and Shooting Stars.* W. F. Denning. (Roy. Astronom. Soc., M.N. 78. pp. 395-400, March, 1918.)—Detailed examination of the principal meteor showers for many years past yields material for deducing mean values of the velocity, height, length of path, etc. The Leonids appear to be usually about 2 miles higher than the Perseids, owing probably to their greater velocity, the observed rates being 47.9 and 38.8 miles per sec. respectively. From a discussion of measurements of 550 fireballs and shooting stars observed in the United Kingdom since 1886, the following mean data are obtained:—

Height at appearance, 72.1 miles.

„ disappearance, 46.8 miles.

Length of path 60.4 miles.

Velocity per sec. 27.8 miles.

C. P. B.

1632. *Radial Velocity Determinations with Objective Prism.* F. Schlesinger. (Amer. Philosoph. Soc., Proc. 52. pp. 175-183, April, 1918.)—Owing to the irrationality of dispersion in prismatic spectra, the length between two predetermined lines will be changed according to the radial velocity of the light source, and with the object of developing a method of utilising the great efficiency of the prismatic camera for stellar spectra work it is proposed to make systematic measurements of the distance between two lines widely separated in the spectrum. This has been suggested by Pickering (*Harvard Annals*, 26. p. 21), but apparently has not been put into practice. Two other methods are also reviewed, and the hope is expressed that the work may be taken up in the near future.

C. P. B.

1633. *On the Real Temperatures of the Stars.* C. Nordmann. (Comptes Rendus, 156. pp. 1855-1856, May 5, 1918.)—Rosenberg's results, dependent upon spectroscopic observations, are, in the following table, compared with the author's results, which are based upon the application of his heterochromatic photometer to the visual rays:—

Name of Star.	Real Temperature in degrees abs.		Spectral Type, after Lockyer.
	Nordmann. Based on r 460 to 630 $\mu\mu$.	Rosenberg. 400 to 500 $\mu\mu$.	
δ Persei	18,500	15,500	Algol
ϵ Persei	15,200	23,000	Crucien
β Persei (Algol)	18,800	12,000	Algol
α Lyræ (Vega)	12,200	22,000	Sirius
α Persei	8800	6500	Polaris
α Ursæ Minoris (Polaris)	8200	5200	Polaris
α Canis Minoris (Procyon)	6800	7000	Procyon
γ Cygni	5620	5100	Polaris
Sun	5820	4950	Arcturus
α Aurigæ	4720	4500	Arcturus
β Andromedæ	3700	2650	Antares
α Tauri	3500	2150	Aldebaran

The agreement, except for α Lyrae, is considered remarkably close. In the author's results, the probable error is proportional to the temperature. The agreement goes to prove that the stars behave as black bodies from one end of the spectrum to the other. Probably the discrepancy in the case of α Lyrae is due to selective absorption of the atmosphere of that star. The figures obtained by Rosenberg and the author confirm N. Lockyer's thermal classification.

H. F. H.

1634. *Recent Observations of Novæ.* E. E. Barnard. (Astronom. Nachr. No. 4655. Nature, 91. p. 882, June 12, 1918. Abstract.)—All the Novæ presenting features distinguishable at the present time have been specially examined, and the details of magnitude, peculiarities of focus, etc., are given in a table extending from T Coronæ (1866) to Nova Geminorum (1912).

C. P. B.

1635. *The Hottest Stars.* A. Pannekoek. (Astronom. Nachr. No. 4657) Nature, 91. p. 487, July 10, 1918. Abstract.)—A close degree of correspondence is found between the spectrophotometric results of H. Rosenberg for certain stars and the class number of the spectral type according to the Harvard classification of Miss Maury.

C. P. B.

1636. *Intensity Distribution of Lines in Stellar Spectra.* K. F. Bottlinger. (Astronom. Nachr. No. 4662, p. 117. Nature, 91. p. 566, July 31, 1918. Abstract.)—Measurements of the structural intensity of stellar spectral lines have been made with a Hartmann microphotometer at the Potsdam Astrophysical Observatory. The work consisted chiefly in the study of H_γ and a few other lines in the spectra of α Canis Majoris, α Cygni, η Leonis, ζ Orionis, δ Orionis, and γ Cassiopeæ. The results are presented in a series of curves representing the distribution of intensity.

C. P. B.

1637. *Stars with Peculiar Spectra.* [Miss] A. Cannon. (Harvard Circular 178. Nature, 91. p. 589, July 24, 1918. Abstract.)—The note contains details of 10 new peculiar stars having bright-line spectra, and 24 stars with composite spectra. Of these latter only four are included in Burnham's General Catalogue of Double Stars. In the same circular it is noted that a photograph of the spectrum of Nova Geminorum (1912) taken on April 5, 1918, shows only slight changes since Nov. 9, 1912, when the brightest band was $\lambda 4868$. Between $\lambda 4886$ – $\lambda 5007$ the spectrum resembles the prevailing type of gaseous nebulae, but differences occur in other portions of the spectrum.

C. P. B.

1638. *Periodic Spectrum of α Canum Venaticorum.* A. Bëlopolsky. (Astronom. Nachr. No. 4664. Nature, 91. p. 589, July 24, 1918. Abstract.)—Details of the epochs of maximum intensity of the dark line $\lambda 4129.08$. The period of variation is about 5.50 days.

C. P. B.

LIGHT.

1639. *Cassegrain Reflector with Corrected Field.* R. A. Sampson. (Roy. Soc., Phil. Trans. 212. pp. 27-66, April 18, 1918.)—A detailed analysis is given of the design of a large cassegrain reflector, 40-in. aperture, equivalent focal length 508 in., with special means of correcting the errors of the ordinary type, and without employing any curves and angles outside those that are already known to work well. This is done by introducing three separated lenses, made of the same glass so as to permit of the total elimination of chromatic aberration. The usual convex reversing mirror is replaced by a weak convexo-concave lens silvered at the back, and about two-thirds of the way between this and the surface of the great mirror is placed a system called the corrector, consisting of a pair of nearly equal but opposite focal lengths, of which the first is double concave, with the lesser curvature first, and the latter nearly plano-convex. All the surfaces are spherical except that of the great mirror, which is intermediate between the sphere and paraboloid. The calculations indicate that with the proposed arrangement spherical aberration, coma, and curvature of field would be completely insensible, and that stars would be represented by strictly circular images of diam. $0.56''$ (arc), at a distance of $80'$ (arc) from the centre of field, and of $2.25''$ at 1 degree distance. C. P. B.

1640. *New Type of Kinematograph Camera.* K. Proszynski. (Photo-graphic Journ. 58. pp. 99-110, March, 1918.)—Dealing first with the principles governing the production of kinematograph effects, chiefly with regard to the elimination of flicker, the article includes a detailed description, with illustrations, of a new type of kinematograph camera, which may be used like a hand-camera, without any supporting stand. To obviate any effect of vibration the front of the camera contains a powerful gyrostatic wheel, thereby keeping the camera very steady in any desired position. The motive power for driving the film is obtained from a set of cylinders containing compressed air, which are fitted in the back of the camera. These supply power to an efficient air motor which runs the film and shutter mechanism. Excellent results were demonstrated at the time of reading of the paper before the Royal Photographic Society. C. P. B.

1641. *Selective Absorption by Coloured Flames.* R. Ladenburg and F. Reiche. (Comptes Rendus, 157. pp. 279-281, July 28, 1918. Ann. d. Physik, 42. 1. pp. 181-209, Aug. 26, 1918.)—Gouy found that the absorption by a coloured flame, of rays similar to those which it emits is far from being complete, and after taking measurements he found that the brightness of the rays could be calculated as a function of the product of the thickness of the gaseous zone and the density of the metallic vapours. The present authors give a comparison of these results with data furnished by the electronic theory of dispersion, according to which the absorption of a homogeneous vapour in a narrow region of the spectrum is caused by resonance centres characterised by their number per cm^3 , their resonance frequency, the mass, charge, and coefficient of decay. According to Lorentz, the equations deduced retain the same values if, in place of a real decay, the regular oscillations are disturbed from time to time by impacts between the

molecules. The authors find their theoretical deductions to be in accord with Gouy's measurements for different coloured flames, and give curves to illustrate this agreement. If the intensity of the rays is examined from the standpoint of Doppler's principle as developed by Rayleigh and not on the electronic dispersion theory, the results disagree with Gouy's experiments. Hence the latter theory appears to offer the correct explanation. H. H. HO.

1642. Refraction and Dispersion of the Halogens, Halogen Acids, Ozone, Steam, Oxides of Nitrogen, and Ammonia. C. and M. Cuthbertson. (Roy. Soc., Phil. Trans. 212. pp. 1-26, April 4, 1918.)—The mean results for the refractivity (at $\lambda = 5461$ unless otherwise stated) of the gases are :—

Chlorine	0.000784	HI	0.0009258
Bromine	0.001157 at $\lambda = 6488$	Steam	0.0002527
Iodine	0.00210 at $\lambda = 6488$	Ammonia	0.0008786
HCl	0.000448	NO	0.0002955
HBr	0.0006149		

It is concluded that the refractive index of pure ozone for the mercury green line is $\mu = 1.00052$. This result is remarkable. For the refractivity of oxygen is 0.0002717, and if the third atom of oxygen on joining the molecule had the same refractive effect as in the normal gas we should expect a refractivity $(\mu - 1) 10^7$ of $\frac{1}{3} \times 2717 = 407.5$. The experimental value 520 is very largely in excess of this, and indicates the existence of interesting peculiarities in the molecule which may probably be ascribed to the linkage. [See also Abstract No. 1180 (1918).] L. H. W.

1643. Law of Blackening of Photographic Dry Plates. E. Kron. (Ann. d. Physik, 41. 4. pp. 751-758, July 17, 1918.)—The quantity of silver bromide which is altered by light is designated the "latent blackening," and it follows from these experiments that it must give different kinds of latent image in the layer, e.g. when two fields differently lighted give equal blackening with one kind of development but not with another; so it is proved that the strength of the latent image cannot be defined by a single number, but is dependent on at least two variables. This dependence of the course of the curve of constant blackening on the method of developing is a further difficulty in the way of the exposure-time relationship as a principle of photographic photometric measurement. A. E. G.

1644. Film Distortions on Small Photographic Plates. F. E. Ross. (Science, 87. p. 647, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—By means of a reseau, tests were made of the film distortions on the small photographic plates used in the photographic zenith tube at Gaithersburg, Md. Air-dried plates showed large irregular distortions, while plates first soaked in alcohol before drying showed much less disturbance. The distortions were found to disappear when the plates were measured wet. C. P. B.

1645. Photographic Sensitising by Blood Pigments. J. M. Eder. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 189-198, Jan., 1918.)—The blood pigments show several characteristic and distinct absorption bands in the visible spectrum, and the present experiments are designed to prove that these pigments behave like other natural colouring matters as photographic sensitisers. The blood pigments are prepared from the red blood corpuscles of a horse, and are

used in weak alkaline solutions in concentrations 1:100 to 1:1000. The plates, sensitised by bromide of silver gelatine, are kept in a bath in complete darkness for 5 mins. and then quickly dried by means of a strong ventilator. It is found that with oxyhaemoglobin and haemin no sensitising action could be proved, but with haematoporphyrin feeble sensitised bands appear. In this case there are two sensitised bands with maxima at $\lambda 660 \mu$ and $\lambda 560 \mu$, while a third maximum occurs at $\lambda 555 \mu$. The absorption spectrum of the haematoporphyrin solution is compared with the sensitised bands produced by it. The action appears to extend from $\lambda 650$ to 500μ . The validity of the law of sensitising action with respect to the connection between absorption and sensitising, together with the usual small displacement of the maxima of sensitising action towards the red side of the spectrum, is proved for this new sensitiser of animal origin.

A. E. G.

1646. *Luminous Efficiency and Colour Index of Black Body.* H. N. Russell. (Science, 87, p. 646; April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—The curves of spectral sensitiveness given by Parkhurst in the "Yerkes Actinometry" make it possible to compute the luminous efficiency of a body radiating according to Planck's law at any temperature. Some provisional results are included.

C. P. B.

1647. *Experimental Determination of the Luminous Energy absorbed in a Photochemical Reaction.* A. Tian. (Comptes Rendus, 156, pp. 1879-1881, June 28, 1918.)—The following arrangement is employed for the measurement of the luminous energy effecting a photochemical change. A thermopile with blackened faces is connected with a galvanometer, the front face being illuminated by the source of light to be used in the photochemical experiments, while the back face can also be illuminated, preferably by the same source of light adjustable by means of a diaphragm. Before the first face is now placed the reaction cell, either empty or containing solvent according as a gaseous or liquid medium is to be used. The illumination on the other face is then varied by regulation of the diaphragm so as to bring the galvanometer reading to zero; this equilibrium position is independent of accidental variations of the source of light when the latter illuminates both faces of the pile. The system to be studied is next introduced, either as gas or as dilute solution, into the cell, the galvanometer reading being proportional to the magnitude to be measured. The values thus obtained may be rendered absolute by subsequent illumination of the front face of the pile by means of a source of known total radiation (a black body, Hefner lamp, etc.) placed at a definite distance, the energy absorbed per sec. for a deviation of 1 mm. on the galvanometer scale being thus measured. Application of this procedure to the photochemical decomposition of hydrogen peroxide shows that no proportionality exists between the amount of chemical action and the quantity of energy absorbed, even when light free from infra-red radiations is used.

T. H. P.

1648. *Luminous Efficiency throughout the Visible Spectrum.* R. A. Houston. (Phil. Mag. 25, pp. 715-722, May, 1918.)—The author describes experiments on fifty different observers from whose results luminosity curves throughout the visible spectrum are derived. These were obtained for illuminations of $\frac{1}{4}$ and $1/6000$ th of a candle-metre respectively, and are plotted on the same diagram as the energy curve. By dividing the luminosity ordinates by the corresponding values for the energy, a curve of luminous

efficiency can be obtained. The max. efficiency was found to be near 0.502 μ in the case of the $\frac{1}{4}$ candle-metre illumination, and near 0.466 μ with the 1/600th candle-metre illumination. All the observers had normal colour vision, and tests on the women students gave substantially the same results as those on the men students.

J. S. D.

1649. *Conditions necessary in order that Pictures may appear True to Nature.* A. Gleichen. (Translated and simplified by G. L. Johnson. Photographic Journ. 58. pp. 188-194, May, 1918.)—A summary of the optical laws relating to the focal lengths and apertures which must be used, the degree of subsequent enlargement necessary, and the distances from which the finished pictures must be viewed, in order that they may appear approximately true to nature.

L. H. W.

1650. *Preservation of Silver Mirrors.* L. Bell. (Electrical World, 61. pp. 1084-1085, May 24, 1918.)—An account is given of the method proposed by Perot for preserving the reflecting power of silvered mirrors [Abstract No. 21 (1910)]. A solution of collodion is poured over the surface, which is then placed in a vertical position to drain. Two mirrors were prepared, having when fresh a coefficient of about 85 %. One was exposed for 15 weeks without treatment, the other for the same time after being coated with the varnish. The coefficients of reflection were then found to be 89.8 % and 70.2 % respectively. It was found that the definition for critical optical work was not deteriorated. Mention is also made of the nickel mirrors suggested by Wood [Abstract No. 209 (1912)].

C. P. B.

1651. *Spherical Aberrations in Objectives.* L. Dunoyer. (Journ. de Physique, 8. Ser. 5. pp. 468-486, June, 1918.)—Discusses the question of lenses of minimum aberration.

L. H. W.

1652. *Rotatory Dispersive Power of Organic Compounds.* Part I. T. M. Lowry. Part II. T. M. Lowry and T. W. Dickson. (Chem. Soc., Journ. 108. pp. 1062-1075, June, 1918.)—Measurements made on a number of organic compounds with rays of eight different wave-lengths lead to the following conclusions:—(1) The rotatory dispersion of a large number of simple organic compounds may be expressed by the formula, $\alpha = k/(\lambda^2 - \lambda_0^2)$, where k is the "rotation constant" and λ_0^2 the "dispersion constant" of the substance. (2) The "rotation constant" k is numerically equal to the "absolute rotatory power," α_0 , which represents the rotatory power of the substance for a wave-length λ such that $\lambda^2 - \lambda_0^2 = 1$. If λ is measured in microns, this wave-length is a little greater than 1 μ or 10,000 Ångström units. (3) The "dispersive power" of a substance is conveniently measured by a unit numerically equal to 100 λ_0^2 . The magnetic dispersive power of the simpler alcohols is about 2 of these units, whilst that of carbon disulphide is 4.8 units. (4) The formula given above can be applied both to magnetic and to natural rotatory powers. (5) The rotatory-dispersion curves for normal substances may be plotted out as simple rectangular hyperbolæ against the squares of the wave-lengths, or appear as straight lines if the reciprocals of the rotatory powers are plotted.

T. H. P.

1653. *Rotatory Dispersive Power of Organic Compounds.* Part III. *Measurement of Magnetic Rotatory Dispersion.* T. M. Lowry. (Chem. Soc., Journ. 108. pp. 1822-1831, July, 1918.)—Descriptions are given of the apparatus

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and methods employed in the measurement of magnetic rotatory power [see preceding Abstract]. The magnet used was a modification of the one designed by Mather for Perkin's classical experiments and was arranged to give substantial uniformity of the strength of field in the region containing the liquids under examination. T. H. P.

1654. *Applications of Polarised Light*. T. M. Lowry. (Nature, 91. pp. 542-546, July 24, 1918. Discourse delivered at the Royal Inst., April 18, 1918.)

1655. *Enhanced Lines of Titanium in Electric Furnace Spectra*. A. S. King. (Astrophys. Journ. 87. pp. 119-129, March, 1918.)—In general enhanced lines of metallic elements are difficult to obtain in electric furnace spectra; for a few elements they appear in the arc under special conditions [see Abstracts Nos. 60 (1909), 1524 (1912)]. By forcing the temperature of the furnace it has now been possible to obtain the enhanced lines there also, and, incidentally, they have been obtained with remarkable relative intensity owing to a breakdown of the resistance tube, thereby giving an arc inside a highly heated cavity. The enhanced lines appear to occur right across the heated cavity, while the ordinary arc lines are strongest near the walls of the tube. Thus the enhanced lines show a distinct lack of dependence upon either temperature-difference or potential-fall. An additional effect of considerable importance with regard to the determination of wave-lengths is the dissymmetry of the lines, especially when reversed; the red component is usually much stronger than that to the violet, and this would materially affect the setting on the lines. C. P. B.

1656. *Extension of Spectrum of Hydrogen*. J. W. Nicholson. (Roy. Astronom. Soc., M.N. 78. pp. 882-885, March, 1918.)—The discovery by Fowler of a new ultra-violet series tending to the same limit as the principal series suggests a peculiarity in that no other element is at present known to give a second principal series of this type. In the present paper additional series formulæ are calculated and the resulting lines are compared with the spectra of Wolf-Rayet stars as being the most authoritative spectrum at present known to show the second hydrogen spectrum. It seems probable from the discussion that all the lines given by the formula $\lambda = \lambda_0 m^2 / (m^2 - p^2)$, where m and p take integral values, are included in the astrophysical spectrum of hydrogen. In particular, this view suggests a very probable origin for the lines $\lambda\lambda 5698$, 4466 , 4684 , 4596 , which are associated with unusual brightness of the sharp series of hydrogen. C. P. B.

1657. *Arc Spectrum of Tellurium*. H. S. Uhler and R. A. Patterson. (Amer. Journ. Sci. 86. pp. 135-140, Aug., 1918.)—The object of the research here dealt with was to determine the lines belonging to the arc spectrum of tellurium and to measure their wave-lengths in terms of the interferometer standards. Fifteen lines have been identified, all in the ultra-violet, ranging from $\lambda 8175.180$ to $\lambda 2081.8$, and all have been observed in the spark spectrum by other investigators. The lines $\lambda 8175.180$ and $\lambda 2769.658$ were differentiated from the neighbouring lines $\lambda 8175.044$ and $\lambda 2769.939$ of tin and antimony respectively. The arc used in the earlier experiments was formed in a specially constructed brass cylinder through which a current of CO_2 was kept flowing, but difficulty was experienced in maintaining the arc. Later, using larger quantities of the metal and working in air in the usual way, it was found

that an arc could be maintained by putting lumps of the metal in a shallow hole in the lower (positive) graphite electrode, using another graphite electrode directly above. The arc is intensely white and shows the various arc-regions (core, mantle, etc.) very clearly. The research is being continued. A. W.

1658. *Energy-distribution in Spectra of Platinum, Palladium, and Tantalum.* G. V. McCauley. (Astrophys. Journ. 87. pp. 164-182, April, 1918.)—A detailed analysis is presented of a series of determinations of the energy spectra of the three metals for temperatures ranging from 1000° abs. to their respective melting-points. The assumed laws of metallic radiation were tested and found inadequate to express the emission of the metals in question. They acquired a minimum reflecting power in the early infra-red, becoming more marked at high temperatures. The dependence of reflecting power upon absolute temperature was shown to be similar for all three metals in the infra-red. In the visible spectrum, however, this dependence was found to be different for the different metals. No direct relation was found to exist between atomic weight and wave-length of max. emission. C. P. B.

1659. *Relative Intensity of Prismatic and Grating Spectra.* J. S. Plaskett. (Science, 87. p. 645, April 25, 1918. Abstract of paper read before the Astronom. and Astrophys. Soc. of America.)—Comparisons were made between the results given by grating and prism spectrographs having the same dispersion at H_{γ} . The chief defect of prismatic trains is the absorption by the prisms. A diffraction star spectrograph would probably be of value for the ultra-violet, and for the red, where prismatic spectra are specially compressed. C. P. B.

1660. *Damping of Series Spectrum Lines.* C. Schaefer. (Ann. d. Physik, 41. 4. pp. 866-870, July 17, 1918.)—A further development of theory given previously [Abstract No. 1287 (1910)]. It can be shown that the number of emissive particles for the lines of a spectrum series must decrease with increasing order number. This is confirmed by the results of Bevan [Abstract No. 869 (1911)] and Ladenburg [Abstract No. 1855 (1912)]. Mathematical treatment shows further that all the lines of a spectrum series are equally damped. Ladenburg's work for the Na lines $\lambda 5890$ and $\lambda 8802$ supports this conclusion. A. W.

1661. *Nitrogen Spectrum.* M. Hamy. (Comptes Rendus, 157. pp. 258-257, July 28, 1918.)—The explanation of the width of the lines emitted by rarefied gases, based on the application of the Doppler-Fizeau principle to the emissive centres, supposed to follow the laws of the kinetic theory of gases, has recently been the object of experimental verification on the part of Buisson and Fabry. If a gas is sufficiently rarefied so that the effect of impacts of the moving particles may be neglected, theory shows that δ is given by the formula $\delta = 0.61\lambda 10^6 \sqrt{(m/T)}$, where m is the atomic mass of the gas and T its absolute temperature. This, or an equivalent expression, is in perfect agreement with the results of Buisson and Fabry, and also those of Michelson for the cadmium lines. The question arises as to whether this formula can be applied to band spectra as well as to line spectra. Using the positive band spectrum of pure nitrogen, it was found that the radiations, in the region considered ($\lambda 4400$ to $\lambda 4100$) give visible fringes with large path-differences. Increasing the path-difference gradually 5 mm. at a time, it was found that the fringes disappeared between 50 and 55 mm. The same values

were found when a field of 15,000 gauss was applied to the discharge tube. The tube was used in a water-bath at a temperature of 20°C ., but the tube itself was probably at a slightly higher temperature. Taking $\lambda = 426 \times 10^{-6}\text{ mm.}$, $m = 14.01$, the formula gives $d/2 = 56.8\text{ mm.}$, a value slightly higher than that found experimentally. The difference is most probably due to the experimental errors, and so it can be concluded that the law as regards the width of the lines applies not only to line spectra, but equally as well to the lines composing the positive band spectrum of nitrogen. A. W.

1662. *Use of Interferometer for Study of Band Spectra.* R. W. Wood. (Phil. Mag. 26. pp. 176-179, July, 1918. Phys. Zeitschr. 14. pp. 681-688, Aug. 1, 1918.)—The author has previously drawn attention to peculiar geometrical arrangements of the Fabry and Perot interference fringes exhibited in photographs of the titanium spectrum made by Pfund. It was then shown that the existence of a symmetrical pattern in such a photograph indicated that the lines were spaced according to some mathematical law, and it was suggested that in this way regularities might be found in very complicated line spectra [see Phys. Zeit. 8. p. 607, 1907]. The bright and dark bands which form the patterns appear to be of a type of interference fringes hitherto undescribed, though they are of the same nature as the shadow bands which appear when any simple periodic structure is viewed through a similar superposed structure. By their aid we can show periodic discontinuities in a spectrum which are beyond the resolving powers of the spectroscope. The manner in which the bands are formed is as follows: Using the carbon arc as the source of light, and focussing the image of the circular ring system formed by passing the light through a Fabry and Perot interferometer upon the slit of a spectroscope, we find the continuous spectrum traversed by vertical dark arcs, convex towards the red end, which are the loci of wave-lengths refused transmission through the half-silvered plates of the interferometer. If the centre of the ring system is at the centre of the slit, the portions of the slit above and below the centre are illuminated by rays which have traversed the air-film between the plates in an oblique direction, and have in consequence a smaller path-difference, the formula for the path-difference being $e = 2T \cos \theta$, in which T is the thickness of the film, and θ the angle which the rays make with the normal. As the plates of the interferometer are separated the dark arcs become narrower and more numerous, until finally the spectroscope is unable to resolve them. If now in addition to the continuous spectrum we have a bright-line spectrum, the lines will cut across the arcs, the light being absent in the line at each point of intersection. These dark spots in the spectrum lines are the cross-sections of the circular interference rings. Photographs of the green and blue-green bands of the Al arc, taken under the specified conditions, are reproduced, and show patterns made up of closed curves of elliptical or circular form. These always appear when the head of the band is on the side of short wave-length. If the band points the other way, the patterns are made up of curves of hyperbola form, as is shown by a photograph of the band of the carbon arc having its head at $\lambda 6165$. Lines which do not properly belong to the series forming the band produce kinks in the patterns. To ascertain the effect which the law governing the spacing of the lines had upon the appearance of the bands in the spectrum, a number of imitation spectra were made by ruling lines with a dividing engine on the film of a photographic plate which had been fixed without exposure, the spacing of the lines being made to follow some definite law. When these plates were

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superposed on the photograph of the spectrum of a white source containing the dark arcs previously alluded to, the symmetrical bands at once appeared. A more extended study of the subject will be necessary before the method can be of much use in the study of band and line spectra. A. W.

1663. *Transmission of X-rays through Crystals.* T. Terada. (Mathematico-Physical Soc., Tokyo, Proc. 7. pp. 60-70, April, 1918.)—The paper contains a fuller account of the results of the experiments on the visual observation of the patterns produced on a fluorescent screen by X-rays reflected from or transmitted through a crystal [Abstract No. 1160 (1918)]. The spots formed by reflected beams are all of elongated shape, the length being nearly equal to the diam. of the undeflected spot. The breadths of the spots are not necessarily greater for thicker crystal plates than for thinner ones. For example, with a plate of alum, 7 mm. thick, the breadth is decidedly smaller than with a plate of rock-salt of 8 mm. thickness. The most interesting feature of the visual observation consists in the motion of the spots which is caused by the rotation of crystals. On rotating the crystal about an axis, the arrangement on circular cones of the reflected beams becomes strikingly conspicuous. One elliptical system of spots after another appears and disappears on the screen. The spots on some ellipses are very faint, while those on others are very bright. The results further show clearly that the appearance of the pattern in any position is closely connected with those directions in the crystals which are crystallographically conspicuous and this method of finding the zonal axes of crystals may be important for practical crystallography. The author works out the method of reconstructing Laue's photograms and of explaining the shape of the spots in a similar way to W. L. Bragg [Abstract No. 989 (1918)]. E. M.

1664. *X-rays and Crystals.* E. Hupka. (Deutsch. Phys. Gesell., Verh. 15. 9. pp. 869-872, May 15, 1918.)—The paper contains photographs showing that the effects due to X-rays falling on a crystal (quartz) are similar to those produced by white light falling on a suitably crossed grating. E. M.

1665. *Reflection of X-rays and Related Phenomena.* M. de Broglie and F. A. Lindemann. (Comptes Rendus, 156. pp. 1461-1468, May 18, Erratum, p. 1642, May 26, 1918. Nature, 91. p. 295, May 22, 1918.)—The paper discusses the effects produced on a photographic plate by X-rays reflected from the face of a crystal. In addition to the well-known reflection the images are often striated by parallel fringes [Abstract No. 1156 (1918)] due, according to Hupka [Abstract No. 1162 (1918)], to rays reflected at successive layers parallel to the surface layer of the crystal. Secondly, very strong marked bands are often observed which must probably be attributed to invisible cracks along the planes of cleavage in the crystal. In discussion of the general theory the authors further point out that reflection on some crystals, e.g. the base of a prism of phosgenite (PbCl_2CO_2), appears to show all the spots a two-dimensional grating would lead one to expect, i.e. only the surface layer appears to come into play. The examination of a series of crystals of the regular system confirms the consequence of all theories and the experiments of various physicists, that the figures obtained must depend only on the position of the plate and the crystal with respect to the primary beam. It appears that it may be taken as a general rule that those crystals composed of elements of lower atomic weight reflect better than those containing heavier atoms. The relative intensity of different spots varies in

different crystals, probably according to the distribution of energy amongst the different wave-lengths in the primary beam. But even in one and the same crystal the intensity of different spots varies according to its position.

E. M.

1866. *Diffraction of Electric Waves by a Crystal*. L. S. Ornstein. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1271-1281, July 15, 1918).—Develops mathematically the theory put forward by W. L. Bragg of the phenomena dealt with by Friedrich, Knipping and Laue [see Abstracts Nos. 989 and 1158 (1918)]. Photographs by Haga are also provisionally noted. These are obtained from rock-salt, ZnS, CaF₂, topaz, and mica.

E. H. B.

1867. *Theory of X-ray Interference*. P. P. Ewald. (Phys. Zeitschr. 14. pp. 465-472, June 1, 1918).—Gives a theory of the interference of X-rays in crystals which resembles that of Laue, but applies to an infinite crystal. The formula for the intensity of the reflected ray assumes a sufficient continuity in the spectrum distribution of the incident radiation, and the strong and almost monochromatic radiation of the antikathode discovered by Bragg must be dealt with separately. The wave-length is of the order of $\frac{1}{10}$ of the grating element.

E. E. F.

1868. *X-rays and Crystals*. I. M. de Broglie. (Le Radium, 10. pp. 186-195, June, and pp. 245-249, Aug., 1918).—A collected account of the author's work on the subject [see Abstracts Nos. 1154, 1155, 1156 (1918)]. A magnetic field of 10,000 gauss had no effect on the patterns obtained with either rock-salt or magnetite. In the paper eleven good reproductions are given of the photographs obtained with various crystals and also with mercury light and crossed gratings. The results show clearly the connection between the theories of the two effects. In some of the photographs the fringes on the spots are noticeable. Hupka explains these fringes as due to interference between the rays reflected successively from a series of planes parallel to the surface of the crystal owing to the incident X-rays being slightly divergent. In a later paper the author hopes to consider evidence as to the wave-length of the rays used.

E. M.

1869. *Experiments on Polarised Röntgen Radiation*. J. C. Chapman. (Phil. Mag. 25. pp. 792-802, June, 1918).—Up to the present all experiments on the rotation of the plane of polarisation have been made using light of a wave-length of the order of that found in the visible spectrum. The results indicate that the magnitude of the rotation in quartz and other active substances varies inversely as some power of the wave-length. On the assumption that X-radiation is merely light of exceptionally short wave-length, it seemed possible that a great rotation of the plane of polarisation might be obtained under suitable conditions. The experiments described were undertaken to test this point. Polarised X-radiation was obtained by suitable orientation of the cathode of an X-ray bulb and a secondary radiator as in the original experiments of Barkla. Iron in a magnetised state, quartz, and active sugar solution were examined, but with negative results in all cases. Iron was shown to absorb a polarised beam of X-rays to the same extent whether magnetised or unmagnetised. The experiments also show that the absorption by a plate of tourmaline is independent of the direction of the optic axis. E. M.

1870. *International Radium Standard*. E. Haschek and O. Hönig-schmid. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2119-2126, Dec., 1912).—VOL. XVI.—A.—1918.

The authors have examined the Ba-content of the radium used by Hönigsmid [Abstract No. 759 (1912)] in his determination of the atomic weight (value 225.95). The spectrum of the salt showed no Ba lines, and from observations of the amount of added Ba necessary to show the lines the authors conclude that the original salt used by Hönigsmid did not contain more than 0.002 % Ba. E. M.

1671. *Alpha-ray Ionisation.* H. N. McCoy. (Phys. Rev. 1. Ser. 2. pp. 393-400, May, 1918.)—A formula is developed for the α -ray activity of a layer of a radio-active solid as a function of its thickness. It is assumed that the air range of an α -particle is diminished in its passage through the solid by an amount directly proportional to the distance it travels in the solid before emerging, and that the ionisation produced is proportional to the $2/3$ power of the distance the α -particle then travels in air. The theoretical curve for the rise in activity with increasing thickness of the layer is almost the same as an exponential curve, although the fundamental equations are entirely different. In the following table the first row gives the thickness (α) of active material expressed as a fraction of the thickness necessary for the max. activity. The second row (A) gives the activity expressed in terms of the max. activity.

α	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
A	0.000	0.284	0.497	0.659	0.780	0.869	0.930	0.967	0.989	0.998	1.000

It is shown that the activity of a film just thick enough to give the max. activity is 0.8 of the activity of the same material spread in a very thin film. The author has also made experiments on U_3O_8 and finds results in good agreement with theory. The weight per unit area just necessary to give the maximum U_{II} activity is found to be 0.01064 gm. E. M.

1672. *Alpha-rays from Thick Layers.* E. v. Schweidler. (Phys. Zeitschr. 14. pp. 505-507, June 15, 1918.)—Calculates the number of α -particles emitted in unit time from unit surface of a plane-parallel plate of thickness h , if the range is R and the number emitted by unit volume is N . The result is $n = \frac{1}{2}Nh(1 - h/2R)$ for $h \geq R$ and $n = NR/4$ for $h \leq R$. The author also finds the law of distribution of the "residual ranges," i.e. the range which the particle would have if the absorptions within and outside the plate were the same. He also obtains expressions for the ionisation outside the plate (which, for $h > R$, is proportional to the $5/8$ rd power of R), and for the radiation of a radio-active plate through an absorbing plate. [Errata, Ibid. p. 728, Aug. 1, 1918.] E. E. F.

1673. *Number of Ions produced by an α -Particle from Polonium.* R. Girard. (Le Radium, 10. pp. 195-198, June, 1918.)—The method of experiment was to measure the saturation current (I) from a silver plate coated with Po and to count the number (N) of α -particles by a scintillation method. The number of ions (X) produced per α -particle is then equal to $X = I/Ne$. The author finds $X = 116,000$ (e assumed $= 4.17 \times 10^{-10}$). This is much smaller than Geiger's value 162,000 [Abstract No. 1547 (1909)] or Taylor's value 164,000 [Abstract No. 1086 (1912)]. The difference appears to arise mainly in the method of measurement since the α -particles ejected nearly along the plane of the source will be partly absorbed. For measurements of the activities of films, therefore, it would appear better to use the author's value. E. M.

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1674. *Active Radiation of Potassium.* H. Thirring. (Phys. Zeitschr. 14. pp. 406-408, May 1, 1918.)—Explains the spontaneous negative charge of potassium observed by J. W. Woodrow [Abstract No. 111 (1918)] as due to a pure Volta-effect. When K and Pt are enclosed opposite each other in a light-tight envelope, they represent a galvanic cell of high internal resistance, since the gas, slightly ionised by the K, behaves like an electrolyte. The e.m.f. is high, as K and Pt are at opposite ends of the Volta series. If Hg is substituted for K, the current should be only about $\frac{1}{40}$ th, on account of the small contact e.m.f. Hg-Pt, and still smaller on account of the feeble ionisation of the gas. The author finds no difference in the e.m.f. when the gas is artificially ionised, and concludes that the spontaneous charge is not due to the emission of particles. The e.m.f. attained is about 2.8 volts, and the internal resistance of the order of 10^{11} ohms. E. E. F.

1675. *Analysis of γ -Rays from Radium B and Radium C.* E. Rutherford and H. Richardson. (Phil. Mag. 25. pp. 722-784, May, 1918.)—Gray has shown that the γ -rays emitted from RaE are able to excite the characteristic X-radiations of certain elements, thus proving the similarity of γ - and X-rays. Rutherford later put forward the view that the γ -rays from radio-active substances are to be regarded as the characteristic radiations of the respective elements themselves, set up by the escape of α - or β -rays from them. The consideration further suggests that several types of γ -radiation may be emitted from the same radio-active product and that each type of characteristic radiation should be absorbed according to an exponential law by an absorbing substance of low atomic weight like aluminium. The present experiments were undertaken to test this point. The source, consisting of either RaEm in a thin-walled glass tube or pure RaC deposited on nickel, was placed in a very strong magnetic field. The electroscope was lined with Al except for a wall of very thin mica, and contained methyl iodide vapour so as to multiply up the ionisation due to soft radiation without appreciably increasing that due to hard radiation. The ionisation curve was determined by interposing sheets of metal, and it was found that in the case of Al the curve could be built up by assuming the presence of various radiations each absorbed exponentially. With lead irregular absorption curves were obtained. With RaC deposited on nickel a soft γ -radiation excited in the nickel by the α -rays was observed, this being shown by experiments in which the RaC was deposited on silver. The results are as follows:—

	Absorption Coefficient in Aluminium.	Mass Absorption Coefficient in Aluminium.	Absorption Coefficient in Lead.
Radium B	$\left\{ \begin{array}{l} 280? \\ 40 \text{ (cm.)}^{-1} \\ 0.51 \text{ " "} \end{array} \right.$	$\left\{ \begin{array}{l} 14.7 \text{ (cm.)}^{-1} \\ 0.186 \text{ " "} \end{array} \right.$	Varying from 11 to 2.8 (cm.) ⁻¹ . 0.50 (cm.) ⁻¹ after traversing 1 cm. of lead.
Radium C	0.115 "	0.0424 "	

The soft radiation of RaB ($\mu/D = 14.7$) corresponds closely to that of Barkla's series L, while the radiation of RaC corresponds to that of series K.

An examination of the γ -rays from all radio-active elements is in progress.

E. M.

1676. *Interference Phenomena with Gamma Rays.* A. N. Shaw. (Phil. Mag. 26, pp. 190-194, July, 1918.)—The experiments aimed at the observation with γ -rays of interference phenomena similar to those of various experimenters with X-rays. Mica was used at almost grazing incidence, and exposures of about a month with 15 mgm. RaBr_2 were given. The photographs show a series of lines besides the main circular image. The effects were observed in one of the directions in which the more intense spots were obtained with very hard X-rays, and no perceptible effect was observed in the direction in which soft X-rays give their strongest reflection. With soft X-rays the "spot" due to reflection at the cleavage planes appears most prominent. With hard X-rays and with γ -rays other spots spring into much greater prominence, presumably by "reflection" from other planes. The author considers that the wave-length of the γ -rays used is between 10 and 100 times smaller than that of the hardest Röntgen radiations. E. M.

1677. *Velocities of δ -Rays.* H. A. Bumstead. (Amer. Journ. Sci. 86, pp. 91-108, Aug., 1918.)—A continuation of previous experiments [Abstract No. 1862 (1912), etc.]. The observations were made by allowing the α -rays from polonium to fall on metal surfaces under various conditions in a very high vacuum. The main part of the investigation deals with high-speed δ -rays. It is shown that when α -rays fall on a metal plate, electrons are emitted with velocities varying continually from a very small value up to 2.7×10^9 cm./sec. which corresponds to a fall of potential of 2000 volts. It is proposed to include under the name " δ -rays" all the electrons which owe their origin to the direct action of the α -rays—the swifter ones as well as the slower ones previously known. When the swifter δ -rays fall upon a solid it emits electrons of slow speed which, in the present paper, are referred to as tertiary electrons. Their number is considerably greater than the δ -rays which produce them. The existence of the tertiary electrons makes it difficult to determine with accuracy the distribution in velocity of the δ -rays. A large number of tertiary electrons come from the source of δ -rays itself, and their presence in the beam of δ -rays makes it impossible to draw valid conclusions as to the number of true δ -electrons of slow speed (less than 10 or 20 volts). The distribution in velocity of the δ -rays between 20 and 1200 volts has also been determined. Between 80 and 500 volts the results are approximately represented by an equation of the form $y/x^n = c$, where y is the number of electrons whose kinetic energy is equal to or greater than x , and $n = 0.75$.

Evidence is given for the view that, in addition to the δ -rays, positive ions are also produced when α -rays impinge upon a metal in a very high vacuum; these ions appear to come from the layer of absorbed gas upon the metal. By maintaining the vacuum for several days the current carried by these ions may be reduced to a small value—from 5 to 10 per cent. of that carried by the α -rays themselves. E. M.

1678. *Ionisation in Closed Vessels.* J. J. Rey. (Le Radium, 10, pp. 137-141, April, 1918.)—After closing the vessel the ionisation was found to decrease to a minimum after about one month, the decrease being shown to be due to the decay of radium emanation. If non-filtered air was used the ionisation first increased for about 4 days, due to dust gradually settling on the walls of the vessel and thus preventing the recombination of ions due to the presence of large nuclei. With regard to variations in the ionisation the results show that when observations were made over 16-hour

intervals the average fluctuations were 2 % ; over $\frac{1}{100}$ -hour, 5 % ; and over $\frac{1}{1000}$ -hour, 7 % . Observations were also made at reduced pressures : a peculiar effect was noticed, in that with decreasing pressure the ionisation first increased slightly to a maximum at about 40 cm. Hg. This is presumed to be due to very easily absorbed radiations emitted by the walls of the vessel.

E. M.

1679. *Bragg Ionisation Curves*. P. Bianu. (Le Radium, 10. pp. 122-125, April, 1918.)—The first experiments show that the range of the α -particles of polonium in air is inversely proportional to the pressure to less than 1 % between pressures of 8 cm. and 86 cm. Hg. Further, the total number of ions produced by the α -particle for complete absorption is shown to be the same between these pressures. The author has also investigated the shape of the ionisation curve when the α -particles have traversed sheets of metal foil, and the results show that the position of max. ionisation is altered by a greater amount than the end of the range. The following are the values of the reduction of range at 26.25 cm. pressure in air by thickness 1μ : Al, 0.45 ; Ag, 0.91 ; Au, 1.25 cm. Under the same conditions the shift of the maximum of the ionisation curve relative to the end of the range is found to be Al, 0.08 ; Ag, 0.14 ; Au, 0.8 cm.

E. M.

1680. *Existence of Uranium Y*. A. Fleck. (Phil. Mag. 25. pp. 710-712, May, 1918.)—The author has repeated the experiments of Antonoff [Abstract No. 1684 (1911)] on a product UrY, supposed to be a small branch product from Ur, very similar in chemical properties to UrX. No trace of the product could be found, and the author considers Antonoff's results as due to the presence of thorium in his uranium. The soft β -rays ascribed to UrY are presumed to have been due to thorium B.

E. M.

1681. *Transformation Periods of Uranium and Thorium*. H. N. McCoy. (Phys. Rev. 1. Ser. 2 pp. 401-404, May, 1918.)—It now appears to be well established that the number of ions, N, produced by any α -particle of range R is closely proportional to $R^{2.5}$ or $N = aR^{2.5}$. The constant a may be calculated from the number of ions known to be produced by an α -particle of polonium, i.e. 168,000. This gives $N = 6.97 \times 10^4 R^{2.5}$. If I is the total ionisation current in amps. of 1 gm. of a radio-active element of atomic weight M and decay constant λ it follows that—

$$\lambda(\text{sec.}) = IM/NF = IM/(6.97 \times 10^4 R^{2.5} F),$$

where $F = 96,600$ coulombs. This gives a method of determining λ , and thus the half-time period. Putting in the value of I for Ur (1 + 2), viz. 4.61×10^{-10} amp., the author calculates the half-time period of UrI to be 5.04×10^9 years. Rutherford and Geiger's value calculated from the number of α -particles emitted is 4.8×10^9 years. For thorium the author deduces a period 1.8×10^{10} years, Rutherford and Geiger's value being 1.81×10^{10} years.

E. M.

1682. *Growth of Radio-thorium from Meso-thorium2*. J. A. Cranston. (Phil. Mag. 25. pp. 712-715, May, 1918.)—The object of the experiment was to establish whether or not there exists an intermediate body between Meso-Th2 and Radio-Th. Additional interest is lent by the fact that Radio-Th corresponds with ionium, the parent of which is experimentally unknown. In the experiments Meso-Th was taken, and the Meso-Th2

separated out and purified by a chemical method based on its analogy with actinium. The growth of α -ray activity of the Meso-Th2 with time was observed, this growth being due to the formation of Radio-Th and subsequent products. The "rise curve" was found to agree well with that calculated on the assumption that Meso-Th2 disintegrates directly into Radio-Th with no intermediate product. The results also suggest the possibility that a few, less than 8 in 10,000, of the atoms of Meso-Th2 may disintegrate with the emission of α -particles. E. M.

1683. *Emanation in Spring Water.* W. Hammer and F. Vohsen. (Phys. Zeitschr. 14. pp. 451-454, May 15, 1918.)—Further data are given concerning Hammer's "fontactoscope" or emanation electroscope [Abstract No. 1580 (1912)]. Accurate values are obtained when the sample of water is left for 8 hours in the vessel before testing. But measurements sufficiently accurate for most purposes (8 or 4 per cent.) can be made after 15 minutes. A table is given for determining the amount of RaEm from the radio-activity of the solid deposits. E. E. F.

1684. *Radium-content of Alabama Coal.* S. J. Lloyd and J. Cunningham. (Amer. Chem. Journ. 50. pp. 47-51, July, 1918.)—The experiments were carried out by the emanation method on eleven samples from different localities. The coal was first heated to remove carbonaceous matter, and the ash then dissolved. The measurements were standardised by the emanation from Joachimstal pitchblende of known uranium-content. The average radium-content per gm. of ash was found to be 2.15×10^{-13} gm., and per gm. of coal 0.166×10^{-13} gm. A large variation in the amount of radium per gm. of ash was observed, the lowest being roughly one-fifteenth of the highest. No relation could be found between the Ra-content and the sulphur, volatile carbon, or fixed carbon-content. E. M.

1685. *Diffraction and Reflection of X-Rays.* de Broglie. (Comptes Rendus, 156. pp. 1758-1755, June 9, 1918.)—Discusses the theory of the effects produced when X-rays fall on crystals. E. M.

1686. *Interference Phenomena with Röntgen Rays.* W. Friedrich, P. Knipping and M. Laue. (Ann. d. Physik, 41. 5. pp. 971-988, Aug. 5, 1918. Reprinted from K. Bayer. Akad. München, Ber. pp. 808-822, 1912.)—[See Abstract No. 1158 (1918).]

1687. *Radio-activity.* E. P. Adams. (Amer. Inst. Elect. Engin., Proc. 82. pp. 1159-1233, May, 1918.)—A series of five lectures furnishing a comprehensive general survey of the subject. L. H. W.

1688. *Radio-activity of the Hot Springs in the Beppu Region, Bungo.* D. Iritani and I. Yamakawa. (Mathematico-Physical Soc., Tōkyō Proc. 7. pp. 82-86, March, 1918.)—[See Abstract No. 86 (1918).]

HEAT.

1689. *Thermal Expansion of Marble*. H. Nisi. (Mathematico-Physical Soc., Tôkyô, Proc. 7. pp. 97-102, May, 1918.)—Rings are cut in several directions from a selected block of Carrara marble. The expansion of these between 0° and 40° C. was found by Fizeau's interferometer. The result for any specimen depends on its inclination to the plane of cleavage of the marble, a negative coefficient being found in some directions. The extreme values of the coefficient are -0.77×10^{-6} and $+11.24 \times 10^{-6}$.

P. E. S.

1690. *Melting-points, Specific Heats, and Latent Heats of Fusion of Alkaline Metals*. E. Rengade. (Comptes Rendus, 156. pp. 1897-1899, June 28, 1918.)—Owing to the uncertainty of some of the thermal data for the alkali metals, the author has made a series of measurements with materials carefully purified. The results are as follows :—

	Na.	K.	Rb.	Ca.
True specific heat (solid)	0.2811+	0.1728+	0.0802+	0.0522+
	0.000288†	0.000142†	0.000153†	0.000137†
True specific heat (liquid)	0.880 (at 98°)	0.1422+	0.0921—	0.0604—
		0.000668†	0.000028†	0.000034†
Latent heat of fusion	27.21	14.67	6.144	8.766
Atomic heat at 0°	6.47	6.75	6.85	6.95
Atomic heat of fusion, L	625.9	578.6	524.8	500.0
Melting-point.....	97.90°	68.50°	89.00°	28.45°
L/T	1.69	1.70	1.68	1.66

It will be seen that the values of the atomic heats increase slowly and regularly with the atomic weights and that the atomic heats of fusion diminish gradually, while the ratios of the atomic heats of fusion to the absolute melting-points exhibit great constancy. The high degree of purity of the metals employed is indicated by their melting-points, which are 1-2° higher than those usually accepted.

T. H. P.

1691. *Relation between the Law of Compressibility of Gases and Coefficients of Expansion*. T. Peczalski. (Comptes Rendus, 156. pp. 1884-1886, June 28, 1918.)—It is shown mathematically that the function $v\phi = f$, which is not constant for true gases at constant temperature, passes through a minimum or max. value if the thermal coefficients of expansion, α , and pressure, β , are identical. The ratio α/β is a function of the pressure, so that—

$$\alpha/\beta = a - b\phi - c\phi^2 - , \text{ etc.,}$$

where a, b, c , etc., are functions of the temperature alone. It follows that $v\phi = A e^{b\phi + c\phi^2/2 + d\phi^3/3 + , \text{ etc.}}$, where A represents the value of $v\phi$ when $\phi = 0$. In its simpler form, $v\phi = A e^{b\phi + c\phi^2}$, this equation is found to be in good agreement with the experimental values for hydrogen, nitrogen, and air. T. H. P.

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1692. *New Forms of the Characteristic Equation for Gases.* T. Peczalski. (Comptes Rendus, 167. pp. 118–115, July 15, 1918.)—The law of compressibility of gases at constant temperature [see preceding Abstract] has now been extended to cases where the temperature varies. The relation then becomes—

$$pv = Ae^{\int_{t_0}^t a_0 dt + bp + cp^2/2 + \dots}$$

where A is a constant. The coefficients c , d , etc., being very small, may be neglected in calculations for pressures up to 50 atmos. without appreciable error. Further, Witkowski's experiments on hydrogen show that above -104° the variation of b is small and may be disregarded, so that the variation of the function vp with t depends practically only on $\int a_0 dt$. The expression $a/\beta = 1 - bp - cp^2 - \dots$ may be written—

$$a = a_0 + a_1 p + a_2 p^2/2 + a_3 p^3/3 \dots,$$

a_0 , a_1 , etc., being functions of the temperature alone. The value of a being constant as regards the temperature, it follows that $vp = Ae^{at + bp}$, a being the coefficient of expansion and b being calculated from the data given above; this equation will represent the transformations of hydrogen between 0 and 50 atmos. and from -100° to $+100^\circ$ or even higher. If v and t are taken to be independent variables and it is assumed that—

$$\beta/a = 1 - b_1/v + c_1/v^2 - \dots \quad \text{or} \quad \beta = a_0 + a'_1/v + a'_2/v^2 + \dots,$$

the characteristic equation becomes—

$$vp = Ae^{\int a_0 dt + b_1/v + c_1/v^2 + \dots},$$

or, if only the first two terms of the development of β/a are taken—

$$vp = \phi(t) e^{(b_1/v) + \dots},$$

which is very similar to Dieterici's equation—

$$p(v - b) = RT e^{-c/RTv}.$$

T. H. P.

1693. *Catathermic Rays.* J. A. Le Bel. (Comptes Rendus, 157. pp. 201–208, July 21, 1918.)—The term “catathermic ray” is applied to those radiations which originate in the interior of certain substances when unequally heated. These experiments show that these rays are not only produced in metals but can be also obtained with sand, and it is further shown that ordinary walls emit a feeble radiation under the influence of temperature-changes.

A. E. G.

1694. *Relation between Geometrical Form and Vapour Pressure, Solubility, and Stability of Form.* W. J. Jones. (Ann. d. Physik, 41. 2. pp. 441–448, June 8, 1918.)—A strict proof of Thomson's law concerning the influence of surface curvature on the vapour pressure of liquids brought forward by von Helmholtz (Wied. Ann. 27. p. 509, 1886), who considered only the simple case of spherical drops and gave the equation, $RT/M \cdot \log(p_2/p_1) = 2\sigma/\rho \cdot (1/r_2 - 1/r_1)$, where p_1 and p_2 indicate the vapour pressures of spherical drops of radii r_1 and r_2 , σ is the surface tension, ρ the density of the liquid, T the absolute temperature, R the gas constant (8816×10^7 erg/temperature), and M the mole-

cular weight of the vapour. The author proceeds to the generalisation of this law, Gibbs (Scientific Papers, 1. p. 815, 1906) having shown that with isotropic solids, just as with liquids, σ represents the work of formation of unit area of the solid-liquid or solid-gas surface. The generalised formula deduced is applied to the consideration of (1) the variation of vapour pressure and solubility with the magnitude of the particles, (2) the heat-changes accompanying changes of surface, and (8) the stability of geometrical forms.

T. H. P.

1695. *Use of Liquid Nitrogen for conveniently producing Temperatures down to -211°C .* G. Claude. (Comptes Rendus, 157. pp. 277-279, July 28, 1913.)—The author demonstrates the ease with which, in the absence of liquid hydrogen, it is possible to attain in a few minutes the solidification temperature of nitrogen, viz. -210°C . The principle adopted is that when a current of air is rapidly passed through a liquefied gas, this is cooled below its normal ebullition point. The process employed is more convenient, rapid, and permits the use of smaller quantities of liquid nitrogen than evaporation *in vacuo*. The liquid nitrogen is contained in a d'Arsonval-Dewar flask into which the extremity of a copper worm dips. The worm is cooled in another vessel by liquid nitrogen and traversed by a current of hydrogen, which is then bubbled through the liquid, thereby producing rapid cooling, e.g. -200°C . after 2 mins., -206°C . after 6, and -210°C . after 12 mins. Experimental conditions are given, which are simple and allow of working with an open vessel.

H. H. Ho.

1696. *On the Law of the Partition of Energy.* J. D. van der Waals, Jr. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1175-1184, May 80, 1913.)—The author has tried to show that it is possible to account for the partition of energy in the normal spectrum with the aid of differential equations, which admit of a continuous emission and absorption of energy, and that it is therefore not necessary for the explanation of the normal spectrum to have recourse to the supposition of quanta, either of energy or of "action." For this explanation it is necessary to draw up a system of mechanics, in which a certain relation takes the place of the equation of Liouville in "classical" mechanics. In order to determine this equation the solution of a certain integral equation is required, which, however, the author has not succeeded in obtaining.

L. H. W.

1697. *Luminosity of Black Bodies at High Temperatures.* C. Nordmann. (Comptes Rendus, 156. pp. 664-666, March 8, 1913.)—Further application of the development of Planck's law to the investigation of stellar temperatures results in the conclusion that taking the effective temperature of Vega (α Lyræ) as 12,200° abs., the temperature of Arcturus will be about 8400° abs. with a superior limit of 8900°.

C. P. B.

1698. *Gas Thermometer as Basis for the Measurement of High Temperatures.* F. Henning. (Zeitschr. Elektrochem. 19. pp. 185-192, Feb. 15, 1913.)

1699. *Thermodynamical Deduction of the Law of Photo-chemical Equivalence.* Einstein. (Journ. de Physique, 8. Ser. 5. pp. 277-282, April, 1913. Paper read before the Soc. franç. de Physique.)

1700. *Recent Theories of Heat and Radiation.* W. Wien. (Washington Acad. Sci., Journ. 8. pp. 278-284, May 19, 1913.)—A general survey.
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SOUND.

1701. *Range and Sharpness of Resonance under Sustained Forcing, and their Variations with Pitch.* E. H. Barton. (Phil. Mag. 26. pp. 111-148, July, 1918.)—Fundamental in the theory of resonance is the result that the response is fuller when the tuning between force and responding system is closer. Further, the diminution of resonance for a given mistuning depends upon the damping of the responding system. The resonance is said to be sharper when this damping is small, or, in other words, the range of resonance is greater when the damping is large. There appears, however, to be another factor affecting range of resonance, viz., the pitch or frequency of the vibrations, and, when the harmonic impressed forces are sustained, this second factor is just as fundamental and inevitable in its influence as the first. The effect of the pitch seems to have been overlooked, and the author shows that the range of resonance, which varies directly as the damping coefficient, also varies inversely as the frequency. The application of this principle extends to any cases of sustained forced vibrations, whether mechanical, acoustical, or electrical, and the object of the present paper is to sketch the necessary theory and illustrate it by a few experiments. It will be found that the principle under discussion throws light upon some apparently anomalous notes obtained on certain brass instruments. Several previous writers have shown that the character of the resonance is a function of the logarithmic decrement of the responding system, but the decrement appears to have been treated as a single quantity measuring the damping, and the possibility of changing the log. decrement, and therefore the sharpness of resonance, by a change in frequency, the damping coefficient remaining constant, seems to have escaped their attention. The mathematical theory is then developed in detail. Illustrative experiments are described which qualitatively show the dependence of resonance range on pitch as well as damping for the three cases, mechanical, acoustical, and electrical, while others yield a quantitative result in corroboration of the theory. The mechanical case was demonstrated by experiments with the double pendulum, the acoustical by Melde's experiment with constant tension and with constant number of segments, by Helmholtz's experiment of the response elicited from a stretched string by a tuning-fork, by adjustable resonators and forks, and by brass instruments, while possible electrical examples are discussed. In the latter case, which might be supposed the most complicated of all, many of the factors are entirely at the experimenter's disposal; thus, by modifying the values of the inductance, resistance, and capacity of the responding circuit, both its frequency and sharpness of resonance to suitable forcing oscillations, provided they are of sustained amplitude, may be controlled. Moreover, this can be done in a variety of ways to fulfil some other condition, such as keeping the inductance at a given value, halving the resistance, or quadrupling the capacity. The author had hoped to make some confirmatory experiments with Fleming's cymometer, but these are postponed for a more extended examination. Tables of results are given for the various experiments. Summarising his results the author states: (1) In the case of vibrations executed under sustained harmonic forcing, the sharpness of response varies directly as the

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frequency of the vibrations it is sought to elicit, provided the damping coefficient remains constant. (2) These relations are held to apply to any forced vibrations fulfilling the above conditions, whether mechanical, acoustical, or electrical. (8) The principle affords a valuable clue to the best arrangement of certain experiments on forced vibrations, whether of a merely qualitative nature for lecture illustrations or of a strictly quantitative character for laboratory determinations. (4) In the case of brass instruments the variation of resonance range with pitch is specially noticeable. It serves to elucidate the apparently anomalous production on certain instruments of a low note, while various other points in the theory and practice of brass instruments are also rendered clearer by the theory. (5) The strongly damped electrical oscillations usually dealt with on Fleming's cymometer lie outside the scope of the simple theory here developed for the response under sustained forcing. H. H. Ho.

1702. *Theory of Combination Tones with Strings and Membranes.* C. Schaefer and E. Juretzka. (Ann. d. Physik, 41. 8. pp. 581-592, June 24, 1918.)—Instead of using Helmholtz's equation, primarily applicable to a particle—

$$d^2x/dt^2 + n_0^2x + \delta x^2 = a \cos pt + b \cos qt \dots\dots\dots(1)$$

the authors use the following more general form—

$$\frac{d^2x}{dt^2} + n_0^2x \pm \sum \delta_{\alpha\beta} \frac{d^\alpha x}{dt^\alpha} \cdot \frac{d^\beta x}{dt^\beta} = a \cos pt + b \cos qt \dots\dots\dots(2)$$

where a and β are any two positive finite integers. In the special cases where $\alpha = \beta = 1$ equation (2) becomes—

$$d^2x/dt^2 + n_0^2x \pm \delta(dx/dt)^2 = a \cos pt + b \cos qt \dots\dots\dots(8)$$

where the vibrations occur in a medium whose resistance is proportional to the square of the speed. The mathematical investigation which follows shows that the behaviour of strings and membranes as regards combination tones is analogous to that of particles. E. H. B.

1703. *Wave Model.* H. Barkhausen. (Phys. Zeitschr. 14. pp. 620-622, July 15, 1918.)—The model consists of a large number of thin rectangular strips of tin, soldered to a thin wire traversing the central line parallel to the narrow edges. The larger and heavier the strips, the slower will a torsional wave travel along the wire. One side of the strips is coloured black and the other white, and they are all originally seen end-on. If the wire is vertical, the lower end may be free. The torsional waves correspond precisely to the modes of vibration of strings and pipes, the succession of original oscillations governing the order of the overtones. Since the damping is feeble, the oscillations are maintained for several minutes. E. E. F.

1704. *Speed of Sound in a Homogeneous Fluid.* Ariès. (Comptes Rendus, 157. pp. 110-112, July 15, 1918.)—Remarks on the form of the expression for the theoretical speed of propagation of sound in a homogeneous fluid.

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1705. *Specific Inductive Capacity and Atomic Charges*. F. Sanford. (Phys. Rev. 1. Ser. 2. pp. 446-456, June, 1918.)—In this and preceding papers the author has undertaken to show that if the mobilities of ions, as calculated from electrolysis be multiplied by their respective ionic masses, numbers are obtained which are closely related to many of the physical and chemical properties of the ions. On certain assumptions these numbers become proportional to the electric charges of the ions and have been spoken of as the characteristic ionic charges. These charges have been shown to be related to all the properties of bodies which depend on cohesion or affinity. In the present paper their relation to specific inductive capacity is discussed. [See Abstract No. 510 (1918.)] E. H. B.

1706. *Electrification by X-rays*. C. G. Bédreag. (Comptes Rendus, 157. pp. 89-91, July 7, 1918.)—The author has made experiments on the electrification of electrodes of brass and silver exposed at low pressures to X-rays. As the pressure is decreased below about 10^{-6} mm. Hg the electrodes become charged with an increasing positive charge which is further increased when the electrodes are placed in a magnetic field. At atmospheric pressure the particular electrodes become charged negatively. E. M.

1707. *On the Approximate Solution of certain Problems relating to the Potential*. Rayleigh. (Phil. Mag. 26. pp. 195-199, July, 1918.)—Mathematical; supplementary to a paper with the same title published in the author's "Scientific Papers" (vol. I, p. 272).

DISCHARGE AND OSCILLATIONS.

1708. *Energy required to Ionise an Atom*. R. T. Beatty. (Phil. Mag. 26. pp. 188-186, July, 1918.)—Using certain assumptions the author calculates the energy required to remove an electron from the atoms of the gases of the helium group. In each case the atom is supposed to consist of a central positive nucleus with charge ne , surrounded by inner rings with $n-2$ negative electrons, and the remaining two electrons at opposite ends of a diam. on an outer ring determining the size of the atom. Accordingly, for all purposes of calculation the atoms of the inert gases can all be represented by a central charge $2e$, and two electrons at opposite ends of a diameter, $2a$. The energy required to remove one of these electrons from the atom is given by $2e \cdot e/a - e \cdot e/2a = 1.5e^2/a$. This corresponds with the energy acquired by falling through a difference of potential E , if $Ee = 1.5e^2/a$. Using Jeans's corrected value for the radius of the He atom and Rankine's relative values of the atomic radii the following values of E are calculated: He, 19.4; Ne, 16.8; A, 11.6; Kr, 10.15; Xe, 8.65 volts respectively. These numbers agree well with the experimental values of Franck and Hertz, viz. He, 20.5; Ne, 16; A, 12. No experimental values are yet published for Kr and Xe. E. M.

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1709. Ionisation in Gases and Gaseous Mixtures by Röntgen and Corpuscular Radiations. C. G. Barkla and A. J. Philpot. (Phil. Mag. 25. pp. 882-886, June, 1918.)—A study of the ionisation produced in gases and in mixtures of gases and vapours by corpuscular radiations and by X-radiations furnishes valuable information regarding the processes taking place during the transmission of these rays through matter. In the first experiments described characteristic X-rays from a radiator (Sn, Ag, or Ba) traversed an ionisation chamber of carbon. The ionisation current was measured, the walls then lined with thin gold-foil, and the current measured again. From these observations the ionisation due to the complete absorption of the corpuscular radiation from the gold was deduced. Experiments were made with several gases and the following values obtained for the relative total ionisation: Air, 100; H₂, 102; N₂, 98; O₂, 110; CO₂, 102; SH₂, 188; SO₂, 96; C₂H₅Br, 160; CH₃I, 148. No change of relative ionisation could be detected when different radiators were used, *i.e.* with different velocities of ionising corpuscles. The authors show that the above figures for the relative ionisations due to complete absorption of corpuscular radiation agree closely with the relative ionisations due to complete absorption of a Röntgen radiation with all its secondary radiations. Accepting as proved that all X-ray ionisation is by means of the ejected corpuscles this shows that the number of corpuscles set free in a gas by a Röntgen radiation which is completely absorbed depends little, if at all, upon the nature of the gas.

Tables are given of the ionisation coefficients for homogeneous X-radiations in various gases. The ionisation in gaseous mixtures due to complete absorption of the corpuscular radiation have also been determined and a consideration of the result shows that the relative absorptions of energy by the gases are in agreement with their relative masses. The ionisation by X-rays of gaseous mixtures is, however, shown to differ considerably from the sum of the ionisations in the two individual gases. The difference shows the effect of corpuscles from the one gas being absorbed by the other. E. M.

1710. Ionisation of Liquid Dielectrics by Radium Emanation. G. Jaffé. (Le Radium, 10. pp. 126-184, April, 1918.)—A silvered cylindrical vessel provided with a central electrode was filled with the liquid under observation, and radium emanation introduced. The ionisation current was measured with a large p.d., and compared with that due to the same emanation in air. From the curve of rise in activity after first introducing the emanation the relative ionisation due to α - and β -rays was also deduced. The results show that in the liquids examined the ratio of the ionisation to that in air is of the order of 1/1000 for α -rays and 1/10 for β -rays. The actual ratio of the ionisation in hexane, CCl₄, and CS₂, for the same amount of emanation was 1 : 0.76 : 2.2. The small amount of ionisation in the various liquids is shown to be in agreement with the assumption that about the same number of ions are produced as in air, but owing to their being produced in columns along the small tracts of the α - or β -rays they recombine to a very large extent. This view is supported by the shape of the current-potential curve. The ionisation current was found to increase with the temperature of the liquid to about the same extent as calculated on the assumption that the only ions which carry the current are those escaping from the "columns." E. M.

1711. Ionisation by Charged Particles. N. Campbell. (Phil. Mag. 25. pp. 808-817, June, 1918.)—The paper deals with a continuation of the author's experiments on δ -rays [Abstract No. 484 (1918), etc.]. It is concluded that

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primary rays of velocity less than 11 volts (fall of potential) do not cause ionisation or liberate δ -rays. Further, δ - or reflected rays never have a speed greater than that of the primary. Experiments were made on δ -rays excited by slow β -rays produced by ultra-violet light falling on a plate. Previous conclusions were verified. The various experimental results are discussed on the basis of the theory of ionisation by moving charged particles, put forward by J. J. Thomson [Abstract No. 1084 (1912)]. It is concluded that, while that theory cannot at present provide a complete explanation of the facts, it is qualitatively in agreement with them, and in no way inconsistent with them.

E. M.

1712. *Conductivity of Salt Vapours.* G. C. Schmidt. (Ann. d. Physik, 41. 4. pp. 678-708, July 17, 1918.)—According to these experiments, carried out on the conductivity produced by the halogen salts of zinc and cadmium, when care is taken to avoid impoverishment by the current and the surface is maintained constant, the conductivity is independent of the time. The increase of conductivity with the time, which is frequently observed at the commencement of a series of observations, is to be accounted for by the gradual manner in which the vapour reaches the sound. The decrease of the conductivity, which has been so often observed after a known time, is similarly to be accounted for by a decrease in the surface and, eventually, by an impoverishment due to the current. The hypothesis previously advanced [see Abstract No. 256 (1911)] that the decrease of conductivity is due to the change of ions into uncharged molecules of the element is not tenable. With constant surface and the avoidance of impoverishment due to current, the conductivity first diminishes with decreasing pressure, and then very rapidly increases. With increase of temperature the conductivity increases very rapidly.

A. E. G.

1713. *Electrical Emissivity and Disintegration of Hot Metals.* J. A. Harker and G. W. C. Kaye. (Roy. Soc. Proc. Ser. A. 88. pp. 522-588, July 1, 1918.)—In some previous investigations, in which all experiments were conducted at atmospheric pressure, the authors obtained evidence showing that under those conditions the carriers of electricity appear to consist almost wholly of "sputtered" matter, and that corpuscles played but a minor, or at any rate an indirect, part [Abstract No. 1417 (1912)]. The present experiments were undertaken with a view to ascertaining to what extent the phenomena observed on a somewhat large scale with carbon can be reproduced with other substances. The strips of metal employed were mostly approximately 5 mm. wide and 5 cm. long between the clamps, the emitting area being about 4 sq. cm. The currents to heat them varied from about 50 to 250 amps., and the voltage across the strip from 0.5 to a maximum of about 5 volts. Full details, with sketch of the experimental arrangements, are given. These experiments on the volatilisation and electrical emissivity of metals are of a preliminary nature. The metals tested were: Platinum, iridium, iron, tantalum, nickel, copper, and brass; carbon was also used. The gas employed was mostly nitrogen at reduced pressures. It is found that emission of positive electricity occurs at temperatures from 1000° to 1400°C. For metals which melt within this range a sudden and marked increase in the positive current often occurs at the liquefying point due probably to the sudden release of occluded gas. This positive current appears to be augmented when oxygen is present. At higher temperatures negative electricity predominates, and increases rapidly with the temperature. The negative

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current attained with iridium at the melting-point is 80 milliamps., with tantalum at 1870° C. 220 microamps., with iron at the melting-point 90 microamps. In the case of carbon in air at atmospheric pressure an ionisation current of 8.5 amps. is obtained. The negative current at moderate pressures appears to be largely increased if the conditions are such that considerable sputtering of the metal occurs. The negative currents are probably a consequence of chemical reaction between the metal and the surrounding gas. During the experiments in which carbon was used it was found that this substance becomes plastic in the neighbourhood of 2500° C., and that at such temperatures it readily sublimates. [See also Abstract No. 1417 (1912).]

A. E. G.

1714. *Canal Rays and Electronic Affinity*. J. Franck. (Phys. Zeitschr. 14. pp. 628-624, July 15, 1918.)—The connection between the position of a gas in the voltaic series and the charge of its canal rays, studied by Stark, Fischer, and Kirschbaum, may be explained by making the following assumption: In collisions between two atoms or molecules in which the kinetic energy is large with respect to the ionisation work of the molecule, the electro-positive molecule loses in general one or more electrons, while the electro-negative molecule acquires them. Thus, on adding electro-negative iodine vapour to electro-positive He- or Hg-vapour, many positive particles with single or multiple charges are produced. The author attempts an explanation of the "retrograde" K_1 and A_1 rays on this assumption.

E. E. F.

1715. *Transmission of Canal Rays through Thin Partitions*. A. N. Goldsmith. (Phys. Rev. 2. Ser. 2. pp. 16-28, July, 1918.)—The object of the research was to attempt to pass the canal rays through a thin diaphragm into a highly vacuous separate chamber where the spectrum of the accumulated gas, if any, could be examined free from disturbances of the electric discharge which produced the canal rays. The method of isolation of α -rays by transmission through thin partitions, so successfully employed by Rutherford, was used in the present research into the nature of the canal rays. Complete details of the apparatus employed are next given. The potentials used were at times so high that it was difficult to secure high insulation because of surface leakage over the glass. Experiments were tried in air, CO_2 , hydrogen, argon, and helium. The argon was prepared by sparking air in the presence of an excess of oxygen, which excess was afterwards removed by yellow phosphorus. Helium was produced with the same apparatus, except that instead of starting with air the gas obtained by heating monazite sand was used, which, being a mixture of air and helium, affords the necessary amount of the latter with ease. Gaede and Geryk pumps permitted reaching and holding a vacuum of less than 0.0001 mm. in the apparatus. Much difficulty was at first experienced in the construction of a thin and yet gas-tight diaphragm. To begin with, Al-foil was used. It was found that the best imported foil was about 0.008 mm. in thickness, and was not at all free from holes. Indeed it was impossible to find an area of more than 8 or 4 sq. mm. which did not have a hole in it. By using the best white Indian mica and carefully splitting it up with a wedge-pointed laparotomy needle, it was possible to obtain sheets of mica of the required dimensions between 0.002 and 0.006 mm. thick, and free from all visible imperfections. These sheets of mica were sealed in place with de Khotinsky cement, which was sprinkled carefully over the sealing metal surfaces in the form of powder and then

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melted into a smooth film, thus ensuring gas-tight contact. Careful tests, repeated many times, established the fact that when the pressure on one side of the diaphragm was 0.0001 mm. the pressure on the other side might be 2000 times as much without any perceptible leakage occurring in intervals of an hour or more. Attempts were made to identify further the moving particles which passed through the diaphragm, by obtaining their electric and magnetic spectra by the method of Thomson and Wien. The apparatus was so arranged that the beam of canal rays was to pass through a magnetic field of known strength, and between Al plates maintained at a known p.d. They were then to strike a fine-grained screen of willemite, where their point of impact was to be marked by a bright spot. A considerable number of experiments with air, hydrogen, and helium showed that no bright spot could be obtained. The pressure and voltage in the tube were varied through the widest attainable limits, and powerful oscillatory discharges were sent through the main tube as well as the unidirectional discharges, while several other modifications were effected without, however, any definite bright spot being detected. The author, as a result of his experiments, draws the following conclusions :—(1) Canal rays made up of ions of hydrogen or helium can be given sufficient velocity to cause them to pass through thin material particles. (2) When the discharge tube is filled with air, CO_2 , or argon, the only rays that pass through a thin partition are hydrogen. (3) When helium is used, both helium and hydrogen atoms pass through the partition, the helium in great abundance. (4) When hydrogen is used only hydrogen atoms pass through the partition, and these in large quantities. (5) The atoms which pass through such a partition are incapable of causing fluorescence on screens.

H. H. HO.

1716. *Electrical Conductivity in Cylindrical Fields at Atmospheric Pressure.* V. Schaffers. (Comptes Rendus, 157. pp. 208–206, July 21, 1918. *Lumière Électr.* 28. pp. 274–275, Aug. 30, 1918.)—To establish the theory of electrical conductivity in a gas at atmospheric pressure one of the most suitable methods is to study a continuous discharge in a field of known properties. The following conclusions are arrived at as the result of a series of observations on the initial potentials and fields in air :—The ratio of the initial positive and negative potentials is by no means determined by the mobility of the ordinary ions ; it varies regularly with the radius r of the wire. For $r = 0.01$ cm. the two potentials are equal. It is only for radii inferior to this that the negative potential is smaller than the positive. For larger radii the converse is true. The nature of the metal seems to be indifferent, at least when the wire is not very fine. The value $r = 0.01$ cm. separates two types with distinct laws. According to the general principles of the theory of ions the current ought to commence when the ions acquire, in a certain fall of potential, the minimum energy necessary to ionise by collision. By analogy with what is known of the discharges in rarefied gases it may be assumed that this fall ought to be 850 volts for a distance which depends only on the mean free path of the gas. It appears from these experiments that the fall of 850 volts plays no part in the initial ionisation at atmospheric pressure except in the case of fine wires. The thickness of the luminous sheath surrounding the wire is found to be between 0.04 cm. and 0.1 cm. ; there appears to be no systematic variation in this value, and it is concluded that the thickness is the same for all wires. It is shown that it is probable that in the discharges studied the masses of the ions are not invariable, but that they depend on the radius of the wire and, without doubt, obey different laws

according as r is greater or less than 0.01 cm. When the radius of the wire is increased indefinitely the initial field tends towards 80,000 volts/cm.—the well-known value of the explosive field between electrodes of great radius of curvature.

A. E. G.

1717. *Electric Dispersion in Benzol, Toluol, and Petroleum.* N. Linnitschenko. (Phys. Zeitschr. 14, pp. 548–555, June 15, 1918.)—Shows by three different wire-wave methods that within the range of half-wavelengths 88 to 85 cm. no dispersion bands occur either in benzol, toluol, or petroleum. The bands found by Colley, Obolensky, and others are within the limits of accuracy, and the large error attending the adjustment of the position of the front of the tank to the half-wavelength in the liquid was not sufficiently taken into account. The so-called methyl-band, supposed to be characteristic of the methyl group, has no real existence. The dispersion band found by Colley in ethyl alcohol is also doubtful, but not his results with water, which were obtained by a different method.

E. E. F.

1718. *Multiple Reflection of Short Electric Waves from Screens of Metallic Resonators.* W. L. Severinghaus and W. S. Nelms. (Phys. Rev. 1. Ser. 2, pp. 411–428, June, 1918.)—The vibrator used was of the Righi type, the selective resonator screens were made by pasting tin-foil resonators on tracing cloth. The conclusions reached are as follows:—(1) The results of multiple reflection of electric waves from selective resonator screens are very similar to those of multiple or selective reflection in the infra-red. (2) Multiple reflection affords a practicable and easy mode of obtaining short electric waves of a very definite period, less damped than the oscillator waves and free from various disturbing influences. (3) The damping coefficient for resonators whose width was negligible compared to their length was found to be 0.15, which agrees with the theoretical value. The experimental value of this coefficient for the Righi vibrator is 1.4. (4) Resonators can be made to oscillate in their first overtone, *i.e.* with a frequency twice that of their fundamental.

E. H. B.

1719. *Resonators for Short Electric Waves.* W. S. Nelms and W. L. Severinghaus. (Phys. Rev. 1. Ser. 2, pp. 429–445, June, 1918.)—The object of this investigation was to determine the relation of the dimensions and distribution of the resonators to the resulting wave-length. It is an application of the multiple reflection method by the same authors [see preceding Abstract]. Its results may be summarised thus:—(1) A change in the distance between resonators along the direction of electric oscillation has very little effect on the period of oscillation of the resonator. (2) For a screen of resonators the ratio of wave-length of the energy radiated to the length of the resonators depends very largely on the separation of the resonators perpendicular to the electric oscillation. (3) An increase in the width of the resonators of a given length scarcely alters the wave-length re-radiated but increases the damping of the oscillation. (4) Any resonator of width less than one-fourth its length may be taken as a linear resonator.

E. H. B.

1720. *Effect of Electrical Oscillations on the Conductivity of Fused Metallic Salts.* C. Tissot. (Comptes Rendus, 156, pp. 1528–1529, May 19, 1918. Rev. Électrique, 20, p. 106, July 18, 1918.)—In experimenting with fused metallic salts, with a view to finding homogeneous substances for use in crystal detectors, the author noticed that when the salt consisted of a bead

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joining two Pt plates, of 4 mm. area and spaced 1 to 2 mm. apart, the resistance, which at first was of the order of 10^6 ohms, does not undergo much change on a p.d. being applied, so long as this is < 1 volt; but above this value the conductivity increases rapidly till the resistance is only some thousand ohms; and the more so the greater the p.d. applied. In the case of lead chloride this state of conductivity was reached in 12 mins. with 1.4 volts, in 2 mins. with 6 volts, and in 10 to 15 secs. with 10 volts applied. The applied voltage can then be progressively decreased down to some tenths of a volt without the conductivity falling back. On subjecting the substance to the influence of electrical oscillations of sufficient intensity the conductivity vanishes suddenly. The behaviour is thus what might be called a slowly self-restoring antioherer action. Other salts found to behave similarly are: thallium chloride, cadmium bromide, the haloid silver salts, silver nitrate. The author points out that owing to the slowness of action, due to the necessity of bringing back the material to its sensitive state, the arrangement is unsuitable for use as a telephonic detector.

L. H. W.

1721. Aluminium Valves at High Frequencies. J. Zenneck. (Phys. Zeitschr. 14. pp. 535-540, June 15, 1913.)—During the "formation" of Al valve-cells the decisive factor is the current density at the Al electrode. With a surface of 8 cm.², the rectifying action may set in within a few seconds, whereas with 100 cm.² it is still quite imperceptible. Every current in the transmitting direction produces a "disforming" effect, whereas every current in the throttling direction produces a forming effect. The stationary state is a state of equilibrium between these two effects. The forming action, for the same current, is usually greater than the disforming action in the opposite direction. This shows that the processes at the Al electrode are not reversible. With a high-frequency alternator the influence of current density is also very marked. Thus, with an effective current of 1.96 amps. and frequency 4000 \sim per sec. the rectifying ratio is 0.084, whereas with 5.86 amps. it is 0.281, and with 8.5 amps. 0.89. The author sketches several arrangements of Al valves as frequency transformers.

E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1722. Thermoelectric Power of Silicon. J. Koenigsberger. (Phys. Zeitschr. 14. pp. 658-659, July 15, 1913.)—The variation in the sign of the thermoelectric power of Si is a secondary phenomenon, probably attributable to intra-atomic magnetic fields. The Si rods examined by the author were all positive towards Cu. They contained some 5.2 % Fe. It appears that when the amount of iron varies, the thermoelectric power increases as the conductivity decreases. [See Abstracts Nos. 1894 (1911), and 1841 (1913).]

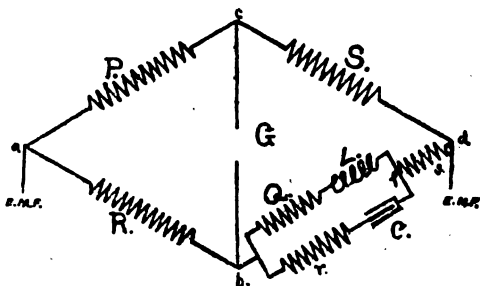
E. E. F.

1723. The Mutual Inductance of Coaxial Circles. J. G. Coffin. (Phys. Rev. 2. Ser. 2. pp. 65-71, July, 1913.)—The formula given is an extension of Maxwell's series formula for the mutual inductance M of coaxial circles. If A and a be the radii of the circles and d the distance between their planes we have $M = 4\pi(Aa)^{1/2}[(2/k - k)F - (2/k)E]$, where $k = 2(Aa)^{1/2}/[(A+a)^2 + d^2]^{1/2}$, and F and E are the complete elliptic integrals of the first and second kind respectively. If we write, $c^2 + d^2 = r^2$, we get from the theory of elliptic functions $M = 4\pi a[\log(8a/r) \cdot P - Q]$, where P and Q are series ascending in powers of $c^2 d^m / a^{n+m}$. Maxwell carried the series as far as $n + m = 8$.

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The author has computed it as far as $n + m = 8$. The correctness of the solution has been tested numerically. In most cases the inaccuracy is less than one part in a million. A. R.

1724. *Method of Comparing Inductance and Capacity.* W. E. Forsythe. (Phys. Rev. 1. Ser. 2. pp. 468-469, June, 1918.)—In comparing inductance and capacity by the ordinary bridge methods it is often difficult to know just what resistances to choose. This is due to the fact that there are generally two conditions of balance, the first the steady current balance, and the second the one due to the reactance; the second condition, in general, depending upon the first. It often happens that the first balance will be



so chosen that the second balance cannot be obtained. In the method outlined this difficulty has been overcome by making the two conditions of balance independent. The arrangement of the circuit is given in the Fig., where P, R, S, Q, r are non-inductive resistances, and L is the inductance to be compared with the capacity C . It is shown that there are three conditions of balance, $S = s + Q$, $S = s + r$, $L = r^2 C$. To balance the bridge make $Q = r$ and then with direct current on the bridge obtain the balance $Q + s = S$. Then with alternating current obtain the inductive balance by shifting from Q to s , keeping at the same time $r = Q$. F: E. S.

1725. *Critique and Study on the Nature of the Volta-effect.* A. E. Hennings. (Phys. Rev. 2. Ser. 2. pp. 1-15, July, 1918.)—Owing to difficulties and uncertainties inherent in the problem, numerous and extensive investigations have as yet produced no satisfactory explanation of the Volta-effect. It is a matter of importance, therefore, that simple and crucial experiments be devised to yield incontestable results. The primary object of this paper is to establish more firmly some of the significant facts rather than to advocate vigorously any theory in regard to the fundamental nature of the Volta-effect. Sanford's results first receive examination, since in a recent article [see Abstract No. 510 (1918)] he has described experiments the results of which, as he interprets them, furnish an effective argument against the so-called electrolytic theory of the Volta-effect. Sanford believes he has shown that the charge exhibited by an insulated conductor, such as a ball, after it has made contact with the inner surface of a hollow earthed conductor, such as a beaker, is dependent on the nature of the outside surface of the latter. This conclusion, upon which Sanford's argument is chiefly based, seemed untenable to the writer because the generally accepted facts of the phenomenon, together with incidental observations in an investigation now going on in this same field, left no doubt in his mind that the Volta-effect depends solely upon the nature of the opposed surfaces. (By opposed sur-

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faces is meant the two metal surfaces which, with the intervening dielectric, constitute the condenser system, the charge upon which is measured in experiments upon the Volta-effect.) The author attempted to reproduce the essential elements of Sanford's experiment. The whole assemblage of apparatus was enclosed in a cage of wire netting, however, and a Dolezalek electrometer used instead of an electroscope. After several series of unsatisfactory observations it was discovered that the silk cord, which in Sanford's experiments served to insulate the ball and to raise or lower it, was invariably charged and decided induction effects produced which could not be eliminated. All the cases described by Sanford were investigated several times but none yielded results which could be interpreted as Sanford interpreted his. In spite of the disturbing influence of the charged cord, there seemed to be no doubt that the Volta-effect depended on the opposing surfaces. It is certain that in Sanford's experiments the true effect was masked to a large extent by disturbing causes. The experimental arrangements were then modified, and complete details of these are given in the paper. In order to do away with the silk cord and the attendant disturbances, it was decided to insulate the metallic beaker instead of the ball and to operate the ball with an earthed wire. It was decided also to study a larger number of cases than had been investigated by Sanford. It was found that the Volta-effect depends, under all circumstances, on the nature of the opposing surfaces of conductors which have been brought near, or in contact with, each other. All, and only such surfaces, or portions of surfaces, of conductors contribute to the general effect. The results of experiments purporting to prove otherwise are spurious. Hence Sanford's chief argument against an electrolytic theory of the Volta-effect fails because of a misapprehension in the premises. The surfaces of conductors which have been discharged to earth act just as though they were definitely and characteristically charged. In the case of a homogeneous surface this postulated electrification is uniformly distributed, while for a surface of dissimilar parts its nature and intensity vary from part to part. The surfaces being the seat of such electrical manifestations, exhibit, as a consequence, a definite p.d., the so-called e.m.f. of contact, between each other. It is only in terms of these p.d.'s that the phenomenon lends itself to quantitative treatment. The effect observed with composite surfaces has been shown to be the average effect of the constituent parts, each of which contributes in exact proportion to its extent, its relative proximity, and its own p.d. with reference to the opposing surface. The effect is practically completely "screened" when the lateral dimensions of the openings in the screen are not greater than their depth. An increase in the ratio from unity upward between the width and depth of the holes results in an increasing effect through the openings. Taken as a whole, the results show that the phenomenon has its seat in the surface. The fundamental question, then, reduces to one in regard to the actual conditions on the surface of a conductor. Is there an insulated electric layer brought into existence by chemical or other means, or are the manifestations due to intrinsic properties of the conductor which make themselves felt at its boundaries? This question is still an open one so far as the present investigation goes. H. H. Ho.

1726. *Galvanometers*. F. Paschen. (Phys. Zeitschr. 14. pp. 521-524, June 15, 1913.)—Gives some details of construction of mirror galvanometers for high sensitiveness and for great range of sensitiveness. A normal sensitiveness of 22,000 divisions per microamp. may be obtained by letting the needles and mirror swing in a vacuum, the period being 10 secs., the scale at

2 m., and the resistance 1 ohm. The author also describes an armoured galvanometer with a mirror 6 mm. in diam., suspended by a quartz fibre only 2 mm. long, inside a copper cylinder into which a copper piston can be introduced for electromagnetic and mechanical damping. This again fits into an iron cylinder for protection against external magnetic effects. The sensitiveness is still 1200. An instrument with a 25-mm. mirror is used for lecture experiments for currents from 100 down to 10^{-8} amps., and another as a voltmeter for 200 to 10^{-8} volts. E. E. F.

1727. *Electrothermal Phenomena at the Contact of Two Conductors: Application to Detectors.* W. H. Eccles. (Phys. Soc., Proc. 25. pp. 278-292; Discussion, pp. 292-298, June, 1918. Electrician, 71. pp. 900-908, Sept. 5, 1918. Abstract.)—A purely theoretical paper in which are deduced the laws connecting the current and the applied e.m.f. in a circuit containing a light contact. [See also Electrician, 71. pp. 1058-1059, Oct. 8, 1918. Paper read before the British Assoc., Birmingham, 1918.] L. H. W.

1728. *Volta-effect.* H. Conrad. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 85-48, Jan., 1918.)—A discussion of the nature of the Volta-effect, the conclusion being that contact theory alone is insufficient to account for the observed relations, but that by help of the chemical theory an explanation is afforded. E. H. B.

1729. *Self-recording Electrometer.* J. Patterson. (Phil. Mag. 26. pp. 200-209, July, 1918.)—Illustrated description of an electrometer in which the principle of the thread-recorder is applied; with results. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

1730. *Magnetic Properties of Vanadium Steel.* J. J. Lonsdale. (Phys. Zeitschr. 14. pp. 581-589, July 1, 1918.)—Using the ballistic ring method, and the vanadium steel first in its original state, then annealed, chilled, and re-annealed, the author found that by heating beyond the critical temperature and either annealing or chilling the magnetic hardness is increased. The permeability is less than that of other steels containing the same amount of carbon, and the hysteresis and coercive force are greater. E. E. F.

1731. *Magnetisation of Manganese, Manganese-Copper, and Chromium.* K. Ihde. (Ann. d. Physik, 41. 4. pp. 829-858, July 17, 1918. Extract from Inaug. Dissertation, Marburg.)—The specimens tested were (1) solid manganese; (2) the same after quenching at 600°C .; (3) another Mn rod quenched and then aged by heating at 140° for 150 hours; (4) four powders of same material as (1); (5) a Mn powder mixed with gypsum; (6) a chemically pure Mn powder; (7) 80 per cent. manganese copper; (8) solid chromium; (9) two Cr powders. These were tested by means of the attraction method in which a cylinder hangs from the arm of a balance, with its lower end between the poles and on the axis of an electromagnet. Formulæ were obtained for determining the susceptibility of both para- and ferro-magnetic bodies, and the curves which are shown for the Mn powders under (4) and (5), the Mn-Cu, and the Cr powders under (9) follow the course of the typical ferromagnetic curve, showing a definite maximum for a given field. In the other cases, the susceptibility diminishes as H increases, and the maximum is already overstepped in fields of 1000 gauss. The ferro-magnetism cannot be ascribed to

the iron-content. Mn has been stated as paramagnetic by Gebhardt, Honda, and Weiss, whilst Seckelson and Weiss have obtained it in the ferromagnetic condition. [See Abstract No. 785 (1910).] G. E. A.

1732. Disappearance of Ferro-magnetism under Short Electric Waves. W. Arkadief. (Phys. Zeitschr. 14. pp. 561-562, July 1, 1913.)—Measurements of the absorption of undamped electric waves by parallel wires show that the difference between magnetic and non-magnetic wires tends to disappear at the higher frequencies. In the case of soft-iron wire, 0.22 mm. in diam., the magnetic permeability for a wave-length of 1.81 cm. is only 8 per cent. of the value for $\lambda = 72.7$ cm. For wave-lengths about 2 cm. nickel possesses a permeability no greater than that of air. E. E. F.

1733. Magnetic Observations during Solar Eclipse, 1912, April 17. G. van Dijk. (Terrestrial Magnetism, 18. pp. 51-53, March, 1913.)—With reference to the observations mentioned by O. H. Tittmann [Abstract No. 989 (1912)] the present note is given for comparison of the magnetograph registrations at De Bilt during the time of the solar eclipse of 1912, April 17. From the character figures for the month of April deduced from 42 magnetic observatories it is shown that the rather quiet beginning of the month was followed by a more or less disturbed period from April 14-20; on April 21 a new series of quiet days began. In spite of the general disturbed condition, the declination curve for De Bilt shows the effect of the eclipse, the increase of the declination in the forenoon being less than ordinarily. Tables are given showing the values of declination, horizontal and vertical intensity for every 5 minutes from 9h. to 15h. (G.M.T.) on the day of eclipse, and a figure showing the changes graphically. C. P. B.

1734. Sun-spots and Terrestrial Magnetic Phenomena. A. L. Cortie. (Roy. Astronom. Soc. M.N. 78. pp. 481-486, April, 1918.)—From a study of the solar phenomena and terrestrial magnetic changes during the period 1898-1911 it is concluded that:—(1) There was a lag of the maximum of frequency of magnetic storms upon sun-spot area, and an inversion of the phenomenon in the latter half of the cycle. (2) After the maximum of a sun-spot cycle the earth is more favourably situated relatively to the zones of spot activity, depending on the inclination of the sun's axis to the ecliptic. (3) The minima in the curve of annual variation of magnetic storm frequency occur near the nodes of the sun's equator, and the maxima near points removed 90° from the nodes. (4) The inclination of the sun's axis to the ecliptic, and the position of the earth relative to the sun-spot zones, would cause such an inequality. (5) A greater magnetic storm is independent of the area of the associated sun-spot and of its position relatively to the central meridian. (6) Spots associated with greater magnetic storms are marked by continual change and by irregularity of structure. (7) Not one, but several, magnetic storms mark the passage of an active spot across the sun, suggesting that the mode of action of a spot is by a series of streams diverging from a disturbed area. (8) In the eclipses of 1898, 1905, 1908 there is evidence that long-enduring belts of solar activity, which were associated with synodical series of magnetic storms, are marked in the solar corona by converging sets of streamers. [See Abstracts Nos. 701 and 877 (1918).] C. P. B.

1735. New Analytical Expression for Magnetic Variation. G. W. Walker. (Roy. Soc., Proc. Ser. A. 88. pp. 191-194, March 31, 1918.)—Since the usual

Fourier representation of the magnetic diurnal variation does not converge rapidly, it may be doubted whether the 12-hour, 8-hour, 6-hour, etc., terms really correspond to a definite physical cause, and it may be that the phenomena are simply diurnal. By trial it has been found that the combination of curves of the form $y \propto \sin t/(1 + k \cos t)$, and $y \propto \cos t/(1 + k \cos t)$ gives a resultant curve remarkably resembling the characteristic declination record for either Kew, Potsdam, or Paris. Working from this it is suggested that the general form—

$$y = -k \frac{(k_1 \sin t + k_2 \cos t)}{1 + k \cos t} + k_2 \left\{ 1 - \frac{1}{(1 - k^2)t} \right\}$$

may prove suitable for the expression of magnetic variations.

C. P. B.

1736. *Coefficient of Magnetisation of Water and Oxygen.* A. Piccard. (Archives des Sciences, 85. pp. 209-281, March; 840-859, April, and pp. 458-482, May, 1918.)—A more detailed account of methods of measurement and results already described [see Abstracts Nos. 518, 519 (1918)].

T. H. P.

1737. *Land Magnetic Observations, 1905-1910.* L. A. Bauer. (Researches of the Department of Terrestrial Magnetism [185 pp.], Carnegie Inst., Washington, 1912.)—The first publication of a series in which it is proposed to publish the results of the operations and researches conducted by this Department.

L. H. W.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1738. *Influence of Variation in Number of Interruptions of Primary Current on the Output of a Ruhmkorff Coil.* Nogier and Regaud. (Archives d'Él. Médicale, 21. pp. 59-68, July 25, 1918.)—With a soft bulb it is shown that as the velocity of interrupter is increased, the current through the secondary increases, while the spark equivalent and the amps. in the primary decrease. With a hard bulb a decrease in the rate of interrupter causes the milliamps. in the secondary to increase; the spark equivalent and the amps. in the primary also increase. The bundle of Röntgen rays is enriched in hard rays, so that in this form the apparatus is at its best for the production of very penetrating rays. These facts are in complete agreement with a theory outlined in the paper.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1739. Electrical Goniometer Furnace for the Measurement of Crystal Angles and of Refractive Indices at High Temperatures. F. E. Wright. (Washington Acad. Sci., Journ. 8. pp. 896-401, Aug. 19, 1918.)—An electric furnace is described which can be mounted on a Goldschmidt's two-circled goniometer and used for goniometric measurements up to 1150° C. The furnace is made of alundum, heated by Pt-wires, and cooled externally by water-jackets. The crystal is mounted in Pt-jaws and adjusted before the furnace parts are set in position. Its temperature is determined by a thermo-element in direct contact with it, the wires being led out through porcelain tubes. Preliminary measurements on a cleavage rhomb of calcite showed that the angle changed from $74^{\circ} 55'$ at 80° C. to $75^{\circ} 52'$ at 800° , the change being about 1 minute of angle for each 10 deg. C.; it is therefore useless to give readings to seconds of arc unless the temperature is also given.

T. M. L.

1740. Optical Investigation of Solidified Gases. III. Crystalline Properties of Chlorine and Bromine. W. Wahl. (Roy. Soc., Proc. Ser. A. 88. pp. 848-858, June 2, 1918.)—Chlorine crystallises in forms belonging to the orthorhombic system, the optical extinctions being parallel and perpendicular to a principal axis: there is also a distinct cleavage parallel to this axis. Polarised light travelling parallel to the cleavage and principal axis is more strongly absorbed, and the transmitted light is of a deeper yellow, with a greenish tint, than is the polarised light passing in directions perpendicular to this principal axis. There is also a slight difference in the degree of absorption in the two directions at right angles to the principal axis. No dimorphic change was observed on cooling the crystals to the temperature of liquid air.

Crystallised bromine resembles chlorine, but its properties are more pronounced. The crystals are orthorhombic, and have a tendency to develop in prisms, with a prismatic cleavage at an angle of about 70° ; at low temperatures there is also a cleavage parallel to the basal plane. The absorption is: Dark brownish-red in the direction of the prism axis, yellowish-red in the direction of a line bisecting the smaller prism angle, and pale yellowish-green in the direction of the line bisecting the larger prism angle. This trichroism is diminished by cooling with liquid air, the brownish-red becoming yellowish-red and then yellow, whilst the yellowish-red becomes pale yellow. No polymorphic change was observed on cooling with liquid air.

Iodine crystallises in the orthorhombic system with a prism angle of $67^{\circ} 12'$. Monoclinic prisms are formed by sublimation below 46.6° C.; this form is also obtained by the rapid evaporation of solutions in CS_2 , CHCl_3 , alcohol and petroleum-ether, but it is probably only a sporadic monotropic modification, as it cannot be produced by cooling the ordinary orthorhombic form even to -180° . The orthorhombic form is strongly trichroic. The light is almost totally absorbed when the direction of the principal axis is parallel to the plane of polarisation; the light transmitted at right angles to the principal axis of extremely thin films is either light reddish-brown or light leather-brown, the colour becoming much paler when the films are cooled.

The study of the melting-point curves has shown that the three elements form a complete series of mixed crystals, and are thus perfectly isomorphous. It is of interest that the strongest absorption in chlorine resembles the weakest in bromine, whilst the strongest absorption in bromine resembles the weakest in iodine. T. M. L.

1741. Chemical Action of the Penetrating (β and γ) Radium Rays. V. Cane Sugar. A. Kailan. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2127-2182, Dec., 1912.)—The experiments show that cane sugar in sterilised tubes is inverted by exposure to the penetrating rays just as in unsterilised tubes [Abstract No. 716 (1918)], but to a much less extent. The diminution of rotative activity and of resulting acids was of about the right amount supposing the H_+ ions to cause the inversion. The resulting solution reduced Fehling's solution. E. M.

1742. Solubility of Radium Emanation in Water. M. Kofler. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2189-2180, Dec., 1912.)—A flask of volume V was taken and filled with volume v of water, and radium emanation introduced. The relative quantities E' and E of emanation present in the liquid and gas above the liquid were measured at different temperatures. The following are the values of the ratio of the concentrations found $a = (V-v)E'/vE$: $0.5^\circ C.$, 0.526; $17.5^\circ C.$, 0.288; $41^\circ C.$, 0.161; $60^\circ C.$, 0.127; $79^\circ C.$, 0.111; $91^\circ C.$, 0.108. E. M.

1743. Concentration of Polonium. F. Paneth. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2193-2194, Dec., 1912.)—The experiments show that polonium can be separated from RaD and lead by diffusion through parchment which retains the Po-salt but lets $Pb(NO_3)_2$ through. E. M.

1744. Solubility of Active Deposit of Radium. E[va] Ramstedt. (Le Radium, 10. pp. 159-165, May, 1913.)—A piece of well-polished and cleaned glass was suspended in radium emanation so as to become activated. After measuring its activity it was dipped in any particular solution for a known interval of time. After carefully drying, its activity was again measured and the subsequent variation with time. From these observations the solubility of the various products was determined. It was found that metals like Au and Pt give anomalous results, presumably on account of adhering gases; consequently glass was used. It was further found that half the activity was easily dissolved while the other half was scarcely soluble, and this is presumed to be due to RaA being first deposited on the glass, and by recoil half the resulting RaB embedded just underneath the surface. With Au or Pt, however, the portion easily soluble under similar conditions was from 60 to 70 %. As a result of the experiments tables are given of the solubilities of A, B, and C in the various reagents. The main conclusions are:—(1) RaC is soluble in HCl , H_2SO_4 , HNO_3 , and acetic acid, less soluble in water, NH_4OH , and Na_2CO_3 , and very little soluble in organic liquids. (2) RaB dissolves easier in water and dilute acids than RaC, less easily in alkaline solutions, and very little in organic liquids. (3) RaA dissolves to a slightly smaller extent in acids than RaC but more easily in organic liquids. (4) The rate of solution increases with temperature and at the same rate for RaB as RaC. (4) Exposure to oxygen diminishes enormously the solubility of the products. E. M.

1745. Active Nitrogen. R. J. Strutt. (Roy. Soc., Proc. Ser. A. 88. pp. 589-549, July 1, 1913.)—To meet the objection that his nitrogen was not free from VOL. XVI.—A.—1913.

oxygen, the author lets his nitrogen stand over phosphorus for hours, until it does not contain 1 part of oxygen in 100,000. The presence of oxygen in his active nitrogen is really injurious, and $2\frac{1}{2}\%$ of oxygen would be fatal. Water-vapour is likewise harmful even in traces; hydrogen and CO_2 have little effect. When vapours of Hg, Cd, Zn, As, Na, S are added to the active nitrogen, nitrides (yielding ammonia) are formed. A stream of CS_2 leads to a deposition of blue NS , and further of brown polymeric CS apparently. The chlorides of sulphur, tin (stannic) and titanium (tetrachloride) give with active nitrogen brilliant colour effects and solid deposits. Many organic compounds, acetylene, benzene, chloroform, ether, etc., yield hydrocyanic acid, but not cyanogen, though cyanogen chloride is formed in the presence of chlorine; benzene seems to yield cyanobenzene. The intensity of the cyanogen spectrum during these reactions is no index of the quantity of HCN formed, and there is in general no connection between the development of the spectra and the chemical action in progress. H. B.

1746. *Preparation of Molybdenum and Tungsten Carbides.* S. Hilpert and M. Ornstein. (Ber. Deut. Chem. Gesell. 46. 8. pp. 1669-1675, 1913. Chem. News, 108. p. 98, Aug. 22, 1913. Abstract.)—When the finely powdered metals (or also the trioxides) are heated in CO or in mixtures of CH_4 and H (the H being added to prevent dissociation of the $\text{CH}_4 \rightleftharpoons \text{C} + 2\text{H}_2$) different carbides are formed at different temperatures. In the case of Mo and CO , MoC is produced at 600 and 1000° ; at 800° the composition varies between MoC and Mo_2C_3 . Tungsten yields W_2C_4 in CO at 1000° ; in a mixture of one methane and one hydrogen, WC is formed at 800° . H. B.

1747. *Do Molecules attract Cohesively Inversely as the Square of the Distance?* A. P. Mathews. (Journ. Phys. Chem. 17. pp. 520-535, June, 1913.)—Mills (Ibid. 15. p. 417, 1911) has shown that for most substances, excepting near the critical temperature, close approximation to constancy is shown by the expression $(L - E)/(\sqrt[3]{d} - \sqrt[3]{D})$, where L represents the latent heat, E the corresponding external work and D and d are the respective densities of liquid and vapour. The author confirms this constancy for a number of substances. The accuracy of the assumption that this constancy demonstrates that molecules attract inversely as the square of the distance depends, however, on the accuracy of the supposition that $(L - E)$ represents only the work done in separating the molecules against their molecular cohesion. The author shows, indeed, that the total latent heat, L , must be composed of three factors, $A + E + I$, where I represents the heat consumed in increasing internal molecular potential energy by expanding the molecule or increasing its energy of rotation. That such expansion does actually occur in passing from liquid to vapour follows from the author's calculations of the values of the van der Waals' constant, b , for pentane, benzene, etc. Hence, it cannot be affirmed that molecular attraction follows an inverse square law.

On the other hand, van der Waals' relationship, $L - E = a(d - D)$, is correct only close to the critical temperature where I is very small and should be changed to the form $L - E - I = a(d - D)$. Unless I is determined independently, this expression cannot be tested for different temperatures, but, as would be expected from it, it is found that $(L - E)/(d - D)$ has increased values at temperatures below the critical one. For hexane the value of I increases from zero at the critical point (284.5°) to 28.21 cal. per 1 gm. at 0° . It is pointed out that, as has been shown by Sutherland, the

correct expression for the increase of molecular potential energy, $a(d - D)$, is deduced very simply on the assumption that the molecules attract inversely as the fourth power of the distance.

T. H. P.

1748. Significance of the Relation between Molecular Cohesion and the Product of the Molecular Weight and the Number of Valencies. A. P. Mathews. (Journ. Phys. Chem. 17. pp. 481-500, June, 1918).—The author has shown [Abstract No. 1096 (1918)] that the value of the van der Waals constant a , which represents molecular cohesion, or of M^2K , which is the constant a for a single molecule, is proportional to the two-thirds power of the product of the molecular weight by the number of valencies of the molecule; in absolute units, $M^2K = 2.98 \times 10^{-27}$ (mol. wt. \times number of valencies) $^{2/3}$. The relationship of cohesion to these molecular properties is now discussed in its theoretical bearings. This relation can be interpreted best, and apparently only, by J. J. Thomson's theory of the electrical constitution of matter and valency, so that cohesion must be regarded as an electrostatic or, more probably, electromagnetic phenomenon. From the results of experiments on the relation between valency and dispersion, Drude [Abstract No. 8241 (1904)] was led to the suggestion that the electron couples constituting the molecules are of two different kinds: (1) those of the atoms themselves, the sum of which presumably gives the molecular weight, and (2) those of valency, which alone are sufficiently free to vibrate synchronously with light and are hence particularly concerned in the refraction and dispersion of light. This conclusion is confirmed by the author's investigation of cohesion.

The general result arrived at in the present consideration of the question is that cohesion, being a function of molecular weight and valency, is a function of the number of electron couples of the valencies and atoms, and is hence probably magnetic in nature. Magnetic substances may be supposed to be those in which, owing to the orientation, or to the polarity, or to both, of the molecules, the cohesive fields of the molecules are not delimited or neutralised by the surrounding molecules, the cohesive attraction thus becoming apparent at distances greater than molecular distances.

T. H. P.

1749. Relation between the Thermal Effect accompanying the Immersion of a Dry Powder in a Liquid, and the Tendency of the latter to Associate. H. Gaudechon. (Comptes Rendus, 157. pp. 209-211, July 21, 1918).—Measurements have been made of the amounts of heat disengaged on immersion of (1) so-called amorphous silica, (2) natural clay, (8) powdered sugar-charcoal, and (4) starch, previously dried at 100°, in water, various alcohols and other organic liquids. It is found that the amounts of heat vary according to the normality or abnormality of the liquids as regards the values of the coefficient K of the Eotvos-Ramsey-Shields relation and of the expression LM/T of the Pictet-Trouton relation. The more abnormal the liquid, the greater is the amount of heat developed, the latter tending towards zero for normal liquids. Thus water, alcohols, acids, and other compounds containing the hydroxyl group give the largest heat-effects, clay giving, for example, ten times as much heat with water as with saturated hydrocarbons. Also, in an homologous series, the thermal effect diminishes as the series is ascended, in accord with the decreased tendency to associate. It is hence evident that the amount of heat disengaged depends mainly on: (1) the abnormality of the liquid, and (2) the ratio of the surface of the solid to its mass, increase of this ratio causing increased evolution of heat.

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T. H. P.

1750. Applications of the Hydrogen Electrode in Analysis, Research, and Teaching. J. H. Hildebrand. (Amer. Chem. Soc., Journ. 85. pp. 847-871, July, 1918.)—Attention is called to the value of the hydrogen electrode as an indicator in titrations, as proposed by Böttger. Apparatus is described whereby titrations can be made with ease and rapidity. Curves are given representing titrations of a number of acids, bases, and salts. These curves illustrate the difference between acids and bases of different strengths, the distinction between normal and neutral salts, and the phenomena of hydrolysis. The curves provide the most reliable method that is known for choosing indicators. The large effect of certain salts and other substances on the colour change of many indicators makes it unsafe to rely solely on calculations from dissociation constants, even where these are known, and the selection of the indicator from tables such as those of Salm. In difficult cases the only sure method is to have the probable indicator present while titrating with the hydrogen electrode, and see if the indicator changes colour at the point of inflection of the curve. The hydrogen electrode can be used alone for titrations where some circumstance such as the colour of the liquid prevents the use of an indicator.

A number of precipitations have been studied by this means, and illustrations are given to show how separations of metals may be predicted and controlled.

A method is described for the rapid determination of magnesium in the presence of calcium.

If instead of a hydrogen electrode an unattackable electrode is submerged in the liquid, it is possible to follow oxidation and reduction reactions. Thus the titration of ferrous iron with dichromate by this method is superior in speed and accuracy to the use of an external indicator. T. M. L.

1751. Criticism of Recent Viscosity Investigations. E. C. Bingham. (Chem. Soc., Journ. 108. pp. 959-965, June, 1918.)—Attention is directed to the necessity of making a correction for the kinetic energy of the liquid escaping from the capillary of a viscometer. A rapid rate of flow is an advantage, as it checks the clogging of the capillary by particles of dust; the velocities required to produce an eddying flow are well known, and it is easy to keep within safe limits.

There is much evidence to show that in simple cases, in which association and dissociation do not come into account, the *fluidity* of a liquid mixture is a linear function of the concentration. If so, it is impossible for the viscosity to be a linear function, and no evidence of chemical changes is afforded by deviations of the viscosity-concentration curves from a straight line. T. M. L.

1752. Correlation of Physical Properties of Solutions. IV. Refraction, Dispersion, and Dissociation of Salts in Water. A. Heydweiller. (Ann. d. Physik, 41. 8. pp. 499-542, June 24, 1918.)—The experimental data for the refraction and dispersion of light in salt solutions are collected from a series of four dissertations and tabulated. The refractive index of a given solution may be expressed by the formula $n = 1.88827 + 4m/800 \cdot \Delta_n$, where m is the concentration in gm.-equivalents per litre, 1.88827 (or $4/8$ approximately) is the refractive index of water, and Δ_n is a constant for a given solute. The formula $\Delta_n = B_n + (A_n - B_n)i = A_n i + B_n(1 - i)$ is given to express the relationship between the refractive power of the solute and its ionisation. The refractive power A_n of the ionised solute is an additive function of two moduli for the anion and kation respectively. These moduli are deduced

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on the assumption that in solutions of hydrogen chloride, the refractive powers of the hydrogen and chlorine ions are in the same ratio (1:5.5) as in the two gases. These moduli are approximately integral multiples of a constant 0.029. The author also discusses the refraction equivalents of dissolved substances according to the formula of Lorenz and Lorentz, with the ionic moduli for this function, the relation of atomic weight to ionic volume and ionic diameter, and finally the dispersive power of salts and of ions in the visible and ultra-violet regions of the spectrum. [See also Abstract No. 1125 (1912).] T. M. L.

1753. Effect of Interionic Forces of the Osmotic Pressure of Electrolytes. S. R. Milner. (Phil. Mag. 25. pp. 742-751, May, 1918.)—A thermodynamical treatment.

1754. Electrolytic Regeneration of Chromic Acid from Sulphate Solutions. P. Askenasy and A. Révai. (Zeitschr. Elektrochem. 19. pp. 844-862, April 15, 1918.)—According to D.R.P. 199,248 and Brit. Pat. 9636 of 1907, G. Adolph and A. Pietzsch avoid, in the regeneration of chromic acid from chromium sulphate in cells without diaphragm, the kathode reduction by adding alkali sulphate or acetate to the electrolytic; the addition is to lower the kathode potential. The authors submit this process to a searching inquiry; they review the literature, and explain under what conditions the process can technically be carried on without diaphragm. The concentration of chromic acid should not exceed 100 gm./litre; when the kathode current density exceeds 200 amps./dm.², which is advisable, no salt addition is required; when not, additions should be made cautiously; the addition of magnesium or of chromium sulphate may be profitable, but it all depends upon the current density and concentration relations. H. B.

1755. Electrolytic Separation of Copper from Tungsten and Molybdenum. W. D. Treadwell. (Zeitschr. Elektrochem. 19. pp. 219-221, March 1, 1918.)—The electrolytic separation of Cu from W and Mo does not succeed in KCN solution. But copper in various salts can be separated from W (as sodium tungstate) in solution of concentrated ammonia by currents of 2 volts, with stationary or rotating electrodes. The separation of Cu from Mo (as ammonium molybdate) requires the presence of alkali sulphite and an e.m.f. of 0.9 volt; the current must in this case be interrupted within a few mins. after the disappearance of the blue colour. The molybdenum trioxide should not be heated above 450°, and not in a Pt crucible; a porcelain crucible should be used. H. B.

1756. Electrolytic Preparation of Calcium and Calcium Alloys. W. Moldenhauer and J. Andersen. (Zeitschr. Elektrochem. 19. pp. 444-447, June 1, 1918.)—Contrary to the usual statements it is possible to obtain metallic calcium free from potassium or alloys with zinc or lead (forming the fused kathodes) from mixtures of the chlorides of Ca and K. The authors study the melting-points of the chloride mixtures. The mixture 85CaCl₂ + 15KCl, melting at 680° C., yields pure Ca or pure alloy (Zn-Ca containing up to 67 per cent. of Ca, and Pb-Ca up to 82 per cent. of Ca), by the Rathenau method and currents of 60 to 110 amps./cm.², at a current efficiency of 90 per cent. maximum. The mixture 40CaCl₂ + 60KCl is unsuitable. The "pure" calcium generally contains less than 0.1 per cent. of potassium, but it may enclose 8 per cent. of the fused electrolyte.

H. B.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

NOVEMBER 1918.

GENERAL PHYSICS.

1757. *New Electric Pendulum.* M. Schanzer. (Zeitschr. Instrumentenk. 88. pp. 218-228, July, 1918.)—Describes a new form of apparatus for electrically maintaining the motion of a pendulum. The energy consumption is very small, only 8 milliwatts; and the ratio of the length of arc during which the pendulum is driven, to the whole swing, is about 1:18, the pendulum thus swinging freely for the greater part of its motion. The pendulum itself is a quartz rod 110 cm. long and 1.8 cm. diam., so that there is only a small variation of length with temperature. The whole apparatus can be enclosed, so that the pendulum can swing *in vacuo* if required. For details of the mechanism see diagrams in original paper. A. W.

1758. *Small Hydraulic Testing Machine.* Genès. (Rev. de Métallurgie, 10. pp. 1142-1146, Sept., 1918.)—Describes, with illustrations, the Schiller testing machine. This is an hydraulic apparatus, with a hand-worked oil pump, the load on the plunger (and hence on the test-piece) being indicated by pressure gauges, one of which has a range of 10 tons and is automatically shut off at that pressure, whilst the other reads up to 50 tons. Compression is obtained between the plunger-head and the inside of the principal framework, which is of the form of a chain link. Ball-impression hardness tests are made in the same way, with the addition of a suitable ball-holder. For tensile tests another framework is added, and tension is obtained between the principal frame and the crossbar of the added frame. Tests upon a ring-shaped test-piece appear to have been primarily considered in the design of the machine. The ring surrounds two saddles formed upon the sides of the plunger-head and cylinder respectively. An extension indicator provided with the machine is sensitive to 1/1000 mm. The writer points out that this form of extensometer only indicates the elastic limit by the method of loading and unloading, and noting whether any permanent set has occurred or not; also he remarks that the frame supplied for tensile tests is too long for ordinary short tensile test-pieces, as it takes a minimum tested length of 10 in. The compactness of machines of this kind, and the adaptability of the present machine to a variety of kinds of testing are its principal merits.

F. R.

1759. Experiments with a Tilling Manometer for Measurement of Small Pressure-differences. J. R. Pannell. (Engineering, 96. pp. 843-844, Sept. 12, 1918.)—The pressure-gauge itself was originally designed by A. P. Chattock [Abstract No. 848 (1901)], and the writer gives some notes in the present paper on its behaviour, and on some improvements which he has made. The gauge consists of a glass U-tube of somewhat unusual form, mounted on a metal tilting frame, photographs of which are given. The pressure-difference is measured by tilting the U-tube instead of measuring the vertical displacement of the surface, errors due to capillarity being thus avoided. Full details of the apparatus are submitted, and the method of using the gauge described with such precautions as are necessary. The gauge is sensitive to a pressure-difference of 0.00006 in. of water, or 0.000002 lb. per sq. in. This head would represent less than 1 % on the velocity of a current of air at 0.4 ft. per sec., as calculated from the pressure in a Pitot tube. The fluids employed in the gauge were pure castor oil and distilled water, but trouble was experienced due to the clouding of the oil. This cloud gradually developed, rendering the gauge very unsensitive, and finally making it impossible to observe the position of the separation surface. After trial of a considerable number of different combinations it was decided that pure castor oil and a solution of ordinary bar salt in distilled water gave the best results. The high viscosity of castor oil is not usually an objection, but where it is, pure benzene can be substituted, though the gauge would be a little less sensitive. Solutions with specific gravities varying from 1.001 to 1.07 were tried, and the 1.07 solution was decided on as the most suitable. Time-sensitivity curves are given, and show that the sensitivity of the castor-oil water-gauge falls off very rapidly. An interesting fact was disclosed in that after the gauge had been subjected to a low temperature for 82 days its sensitivity increased with rise of temperature due to the fact that at low temperatures the clouding condition causes loss of sensitivity. Height-sensitivity curves for three gauges of different dimensions are also given, and show the gauge to be most sensitive with a moderately high bubble—a result confirmed by a mathematical investigation of the subject by Jones, of Madras. Modifications of the gauge finally receive attention. H. H. Ho.

1760. Seismographic Apparatus. B. Galitzin. (Acad. Sci. St. Pétersbourg, Bull. 11. pp. 665-676, June 15, 1918.)—Observations are recorded as made with two instruments of the author's type for vertical movements, using galvanometric registration. A plate is given showing the character of the very open record. C. P. B.

1761. Method of Increasing and Controlling the Period in Vertical-motion Seismographs. F. A. Perret. (Amer. Journ. Sci. 86. pp. 297-300, Sept., 1918.)—To obtain a satisfactory vibration period in seismographs for recording vertical motion, the designers of such instruments are generally under the necessity of employing, for the suspension of the weight, a long and sensitive spring under strong tension. The use of such a spring, however, introduces a very serious defect in the practical working of the instrument, viz., a lack of stability in the position of rest due to the effect upon the spring of variations of temperature. The result is a continual wandering of the recording lever from its normally central position, which cannot be obviated by even the most ingenious compensating devices. Furthermore, there is the inherent difficulty of the large amount of spring required, whereby any slight alterations are magnified sevenfold. It occurred to the

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author that the variations of a magnetic field—due to relative motion of the parts of an instrument in action—might be utilised as a counter-influence to the action of a coarse and stiff spring, thus permitting the use of one so short and robust as to be free from extreme sensitiveness to temperature and other variations. The details of the apparatus, which is still in the experimental stage, are then carefully described. Anticipating a possible criticism, the writer states that he cannot believe any variations of terrestrial magnetism or action of telluric currents at the time of an earthquake could adversely affect his apparatus. So far the author has only applied magnetic control to seismographs for vertical motion, but it is conceived that, in many cases, a horizontal pendulum would be the better for a more positive self-centring factor in the pendulum *per se*, the period then being increased to any desired value by the magnetic control.

H. H. HO.

1702. *Horizontal Flexure of Meridian Instruments.* B. Baillaud. (Comptes Rendus, 157. pp. 198-196, July 21, 1918.)—A method of determining the flexure of meridian instruments is outlined, involving the measurement of collimation readings of the eyepiece micrometer and circle for a series of multiple reflections from a plane mirror and mercury bath, the line of intersection of the two reflecting surfaces being adjusted perpendicular to the meridian. The method is to be tried with the large meridian circle at the Nice Observatory.

C. P. B.

1703. *The Molecular Air-pump.* W. Gaede. (Ann. d. Physik, 41. 2. pp. 887-880, June 8, 1918.)—The pump itself has been described in Abstract No. 1606 (1912), and little additional information is here given; the second part of the paper, however, deals with certain points in the kinetic theory of gases. Some confirmation of the correctness of the view that the action of the pump depends upon molecular movements is afforded by temperature measurements conducted by the author. As the temperature of a gas depends upon the velocity of the molecules, a thermal kinetic effect should be observable in the molecular pump corresponding to its hydrodynamic effect, even if no temporary variations of pressure occur. When the cylinder [see Fig. in Abstract No. 1606 (1912)] rotates clockwise, the gas molecules should strike the upper surface of C with increased velocity, and the lower surface with diminished velocity, and the upper surface should become warmer than the lower surface. By the aid of a thermo-couple these kinetic heat-differences were actually proved to exist so soon as the pressure was sufficiently low to allow the free paths of the moving molecules to become larger than the dimensions of the groove; this takes place when the pressure sinks below 0.001 mm. At this pressure the volume of air removed per sec. has its max. value of 1880 cm.³. This kinetic heat effect, the author points out, is meteorologically interesting. A meteorite passing through the upper atmosphere is under the reversed conditions of the blade C, because the meteorite rushes at great speed through the relatively stationary air molecules, whilst in the pump the blade is at rest and the molecules are being rushed. Accepting the meteorological data of Wegener, the author calculates that temperatures of about 5000° and 8000° C. would be attained by meteorites at altitudes of 100 km. and 200 km. respectively, owing to the kinetic heat effect.

L. H. W.

1704. *The Large Comparator of the German Imperial Standards Verification Commission.* W. Kösters. (Zeitschr. Instrumentenk. 88. pp. 233-247, Aug., 1918.)—Illustrated description.

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1765. *Simple Comparator for Testing of End-gauges up to Five Metres in Length.* W. Breithaupt. (Zeitschr. Instrumentenk. 88. pp. 226-227, July, 1918.)

1766. *Gyroscope Mechanism.* J. W. Gordon. (Engineering, 96. pp. 275-277, Aug. 29, 1918.)—Describes an arrangement by which the gyroscope may be used to turn an applied *moment of force* through a right angle as a bell-crank lever turns a force through a right angle. E. H. B.

1767. *Measurement by Radio-telegraphy of the Difference of Longitude between Paris and Washington.* B. Baillaud. (Comptes Rendus, 167. pp. 165-171, July 21, 1918. Lumière Électr. 28. pp. 205-208, Aug. 16, 1918.)—This is a report presented to the Academy of Sciences of the results obtained by a French Mission under the direction of Renaud and Bourgeois. The radio-telegraphic stations at the Eiffel Tower and at Arlington were respectively utilised. The astronomical observations were made with the prismatic astrolabe and chronometer. The radio-telegraphic comparisons were made during the observations by a third operator who had to compare his chronometer with those of the Marine and War Departments, which made separate observations, by the method of coincidences. To these three groups at each station was added at Arlington the photographic registration of the signals. The radio-telegraphic comparisons were made by means of 800 signals constituted of lines of half a second of which the commencements, spaced regularly about (1—1/120 sec.), properly speaking, formed the signals. The two stations sent alternatively like signals by groups of four. Of the dozen series of trials three were absolutely fruitless owing to disturbances by extraneous transmissions; five were partially satisfactory; but only the series of March 28 and April 1 were completely satisfactory on both sides. These have permitted of sufficiently precise determination of the duration of the time of transmission between the two stations, distance 6175 km. The values obtained for the double of this, duration were respectively 0.066 sec. and 0.068 sec. The last was adopted as being the most trustworthy. The observations of the War Department made the corresponding value to be 0.04 sec. The difference of personal equation between the two observers of the Marine Department respectively at Paris and at Washington was determined by a series of observations comprising 60 stars. It was found to be 0.065 sec. Making allowance for the above and other possible sources of error which are referred to in the report, the new determination of the difference of longitude (1918) is larger by 0.046 sec. than the old. Regarding the photographic registration of the signals at Arlington, experience showed that the rhythmic signals from Paris were sufficiently intense and could be distinguished from atmospheric disturbances except when the latter were very strong. E. O. W.

1768. *Stretching and Breaking of Sodium and Potassium.* B. B. Baker. (Phys. Soc., Proc. 25. pp. 285-288; Discussion, p. 288, June, 1918.)—When stretched, wires of sodium or potassium do not collapse to a point or break off suddenly, but collapse from two opposite sides into a chisel end, just as Andrade found with wires of solid mercury. Further, when the sodium or potassium wire is prepared by allowing the molten metal to solidify in a narrow glass tube and removing by means of a rod, it exhibited when stretched two sets of equidistant, encircling rings, crossing one another and lying in planes, making an angle of about 45° with the axis of the wire. Members of the two sets touch along the line of greatest thinning and bisect each other

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along the line where no thinning occurs. As the wire is stretched to the breaking-point, the rings become more clearly marked but remain unchanged in position or slope. One set of rings is usually much more distinct than the other. Mercury wires also exhibit two sets of rings, which are here very much finer and closer together than with sodium or potassium. These wires thus appear to exhibit the behaviour of plastic metals in one direction and that of brittle metals in the perpendicular direction. The author suggests that the portions of the metal brought into play are in the form of cubes, which, when placed so that a plane through two opposite edges is parallel to the axis of the wire, would allow of lateral contraction by faces sliding one over another in one direction only and not in the direction at right angles.

T. H. P.

1769. *Density of Aluminium*. F. J. Brislee. (Faraday Soc., Trans. 9. pp. 162-178, July, 1918. Engineering, 95. pp. 780-781, June 6, 1918).—Numerous determinations show that generally the density of aluminium is increased by annealing and decreased by cold working; the following are some examples, each the mean of several determinations [see also Abstract No. 1808 (1912)] :—

Condition of Aluminium.	Density.
As cast	2.7059 \pm 0.00044
Same, annealed 14 hours at 450°	2.7080 \pm 0.0002
Same, annealed twice „	2.7087 \pm 0.0002
Same, annealed 8 times „	2.7080 \pm 0.0002
Wire, hard drawn	2.7026 \pm 0.0004
Same, annealed at 450°	2.7057 \pm 0.0005
Sheet, as rolled cold.....	2.7076 \pm 0.0002
Same, annealed 2 hours at 560°	2.7086 \pm 0.0002
Same, annealed 22 „	2.7085 \pm 0.0001

Several photomicrographs show the structures of the samples. The ingot as cast or annealed is polyhedral; so also is the worked and annealed metal. The structures of the cold-worked samples were apparently amorphous, but the hot-worked metal showed elongated grains. It is considered that the density changes agree with the theory of the production of the amorphous state. The return to the crystalline condition by annealing is relatively slow.

F. R.

1770. *The Transition from the Elastic to the Plastic State in Mild Steel*. A. Robertson and G. Cook. (Roy. Soc., Proc. Ser. A. 88. pp. 462-471, July 1, 1918).—The sudden extension of the test-piece and the accompanying drop of the beam of the testing machine, indicates that some reduction of the stress in a specimen of mild steel takes place at the yield-point. An arrangement has been designed ensuring axial loading and limiting the extension after yield by causing the load to be taken jointly by the test-piece ($\frac{1}{8}$ in. diam.), and two bars of mild steel ($\frac{1}{8}$ in. diam.). Extensometers were attached to the latter, so that the load occurring in them at any time was determinable. When the specimen yielded, an increased load was taken up by the two bars from which increase the percentage reduction of stress in the test-piece before and after yield was calculated and found to be as high

as 86 and as low as 17. In the majority of cases (9 in 12), however, the values ranged from 24 to 30. These variations are ascribed to (1) slight deviation from truly axial loading, and (2) slight variations in composition or heat treatment of the material. A test made with a modified Martens' extensometer indicates that the "drop" is a phenomenon associated with the breakdown from the elastic state, and that the reduced stress remains at a fairly constant value over a total strain equal to several times the magnitude of the elastic strain. The case of non-uniform stress was also studied in bending and torsion. In bending the reduction of stress lies between 25 and 88 per cent., while in torsion it is probably somewhat greater than 25 per cent.

F. C. A. H. L.

1771. Flow of Anisotropic Liquids in a Magnetic Field. M. W. Neufeld. (Phys. Zeitschr. 14. pp. 646-650, July 15, 1918.)—Since, according to Bose's swarm theory, anisotropic crystals set themselves parallel to a magnetic field, and should experience less viscous resistance to flow when pointing along a capillary tube, the author examined the capillary flow of anisaldazin and *p*-asoxyanisol in a magnetic field under pressures of 9 cm. and 51 cm. Hg. No effect of the magnetic field could be observed. This indicates that Bose's swarms are much smaller than hitherto thought. That being so, a new explanation of the connection between pressure and outflow must be sought.

E. E. F.

1772. Stationary Flow of Compressible Fluids. O. Janzen. (Phys. Zeitschr. 14. pp. 689-648, July 15, 1918.)—A theoretical investigation of the resistance of air when it can no longer be regarded as incompressible. A cylinder is placed in a uniform current with its axis normal to it. It is shown that up to velocities of some 100 m./sec. the compressibility of the air exerts very little influence upon the stream-lines; but this influence increases with the square of the speed. The cylinder experiences no resistance to its motion except that due to viscosity. The method used by the author is that of the velocity potential. The same method can be used for the solution of other problems concerning compressible fluids when the solution for incompressible fluids is given.

E. E. F.

1773. Distribution of Stress due to a Rivet in a Plate. E. G. Coker and W. A. Scoble. (Inst. Naval Architects, Trans. 55. pp. 207-218, 1918. Engineering, 95. pp. 489-442, March 28, 1918.)—A further application of the author's photoelastic method of investigation [see Abstract No. 906 (1918)].

L. H. W.

1774. Reflection of Shearing Deformation at the Boundary of Two Liquids. A. Finzel. (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 645-657, Aug. 15, 1918.)—A theoretical investigation followed by an experimental examination of the reflection with mercury and with glycerine; approximate agreement between theory and experiment being found.

L. H. W.

1775. Oscillations about a Position of Equilibrium. H. J. E. Beth. (Phil. Mag. 26. pp. 268-324, Aug., 1918.)—Mathematical.

1776. Two-dimensional Motion of a Frictionless Liquid. W. B. Morton. (Roy. Soc., Proc. Ser. A. 89. pp. 106-124, Aug. 19, 1918.)—A theoretical paper which should be referred to in the original.

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1777. *Distribution of Wind Velocity about a Circular Rod.* J. T. Morris. (Engineering, 96. pp. 178-181, Aug. 8, 1918.)—Describes investigations made with a hot-wire Wheatstone-bridge apparatus. The results obtained are illustrated by elaborate polar curves which show the forward cushioning and rear screening influence of the rod in a transverse wind current near the surface of the rod. These influences tend to disappear as the distance from the rod increases. The original article should be consulted, as the diagrams are not suitable for reproduction. C. A. B.

1778. *Structure of Diamond.* W. H. Bragg and W. L. Bragg. (Nature, 91. p. 557, July 31, 1918.)—The authors have applied the new methods of investigation involving the use of X-rays to the case of the diamond, and have arrived at the knowledge of its structure, which is extremely simple, as follows:—Every carbon atom has four neighbours at equal distances from it and in directions symmetrically related to each other. The directions are perpendicular to the four cleavage or (1.1.1.) planes of the diamond; parallel, therefore, to the four lines which join the centre of a given regular tetrahedron to the four corners. The elements of the whole structure are four directions and one length, the latter being 1.52×10^{-8} cm. If the structure is looked at along a cleavage plane it is seen that the atoms are arranged in parallel planes containing equal numbers of atoms, but separated by distances which alternate and are in the ratio 8:1 (viz. 1.52 and 0.51 each $\times 10^{-8}$ cm.). It is a consequence of this arrangement that no second-order spectrum is reflected by the (1.1.1.) planes, although spectra of the first, third, fourth, and fifth orders are found. It was this fact that suggested the structure here described. Several tests may be applied and all are satisfied.

Zincblende appears to have the same structure, but the (1.1.1.) planes contain alternately only zinc and only sulphur atoms. In this way the crystal acquires polarity and becomes hemihedral. E. H. B.

1779. *Formation of Molecules from Thomson's Atoms.* A. C. Crehore. (Phil. Mag. 26. pp. 25-34, July, 1918.)—The equilibrium configurations for various numbers of electrons, as calculated by J. J. Thomson, are such as would result from the assumption that electric force is propagated with infinite speed instead of with the speed of light. The investigations here considered, however, lead the author to believe that this assumption will not essentially modify the configurations, while it greatly simplifies the formulæ. It is therefore adopted by the author, together with the assumption that the rings of electrons are true circles. The experimental evidence, however, suggests that they are not true circles, except in combinations containing only a single ring, but only approximately circular. If this is a fact, the theoretical difficulties are increased. To use such atoms as a basis for calculating the molecules of compounds we must know the relative radii of the orbits of the various electrons, and their exact equilibrium positions. The author attempts to obtain these data approximately by means of experimental models of atoms in which all the electron orbits are in the same plane. The difficulties of the solution almost necessitate this assumption, and the results seem to indicate the probability of its being the actual arrangement. The equilibrium configuration being experimentally obtained and measured, the electrostatic forces between them are calculated, and to these are then

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added the separately calculated forces brought into play by the orbital motions.

The author states the experimental problem to be solved as follows :—
“Given a number of equal bodies confined to one plane and perfectly free to move in that plane without friction, where will each come to rest in stable equilibrium if we suppose that they are acted upon by forces obeying two different laws? First, that each body is attracted toward one common centre by a force proportional to its displacement from that centre; and second, that each of the bodies repels each of the others by a force inversely proportional to the square of the distance between them. These are the assumptions made with reference to the electrons within the sphere of positive electrification of the atom.” In the floating magnet figures these conditions are obviously very imperfectly fulfilled, and the central rings are found to form sooner, as magnets are added, than as calculated. The author replaces the magnets by electrostatically charged spheres of steel or Al turned to uniform gauge with the greatest accuracy attainable. The spheres were suspended from fine copper wires, or from silk fibres moistened with glycerine, and charged to between 5000 and 10,000 volts. A storage battery would have been the ideal source: the actual method employed was connection, by means of a synchronous motor, to alternating potential at selected points of its phase, with condenser charged and discharged at each cycle, the rapidity of succession being such as to make the application of the power in effect continuous. The spheres were immersed in castor oil, having the specific inductive capacity 4·7, and which is, moreover, viscous at ordinary temperatures, and therefore prevents oscillation. It is also quite transparent, which is advantageous for securing photographs. The figures were then controlled so as to make them agree with the calculated ones, the method finally adopted for control being to surround the whole system by an iron-wire screen 80·5 cm. in diam. and 58 cm. high resting upon a flat steel plate, the distance of which below the spheres was adjustable. With a single ring the charges will, from symmetry, be equal. With more rings the relative charges should be measured, but this has not yet been done. Photographs and interesting curves of experimental results are given, serving by their smoothness to test, in a measure, the experimental work. Take, *e.g.* the curve through the stable combinations 6-4, 7-4, 8-4, 9-4, 10-4, showing a systematic law of change, jumping suddenly, for 15 electrons, to the next broken line.

To indicate calculation procedure consider a pair of atoms, each containing two electrons within a positive sphere, placed with the axes of their orbits coincident, and their planes parallel, with the electrons in phase, all lying in the same meridian plane. A series is then obtained giving the electrostatic force between the atoms as a function of the distance; and the total force, controlled by the principal term, is found to be a repulsion varying as the inverse sixth power of the distance. The revolution of the electrons around the common axis gives rise to an attraction, superimposed on the repulsion, and varying as the inverse fourth power of the distance. At the balancing point the equilibrium is found to be unstable, and the fixed distance at which stable equilibrium is finally attained depends on the orbital speed, and is probably many times greater than the radius of the orbits. This distance between the atoms may be regarded as of the order of magnitude of the dimensions of molecules, which are therefore of an entirely different order of magnitude from the atoms of which they are composed. With increasing distance the electrostatic attraction will become less than the gravitational attraction varying as the inverse square. There is, therefore, a second critical

distance, accounting for the existence of the *molecular range*, at which the law of gravity changes. In calculating the forces between the atoms, the atoms are assumed to remain sensibly at a constant distance during several revolutions of the electrons in each, and so expressions are obtained for the instantaneous values of the four component forces as functions of the time. These are resolved along the line joining the centres of the orbits; perpendicular to this line in the plane of the meridian of e ; and perpendicular to each of these directions along the circle of latitude. The averaging of the first of these components over a long period of time gives the attraction, or repulsion, along the line of centres, which the two electrons contribute to the force between the atoms. When two atoms are in equilibrium forming a molecule it is shown that if their electrons are displaced a little from a fixed phase relation, the moment of the forces tends to return them to their original phase relation, and they are again in phase equilibrium. The author considers that if the periods are nearly the same they will become synchronised during the process of forming a stable molecule, so that the solution of the equations on the assumption of equal angular velocities is of primary importance. The parallelism of the orbital planes is a condition of stable equilibrium. If the axis of rotation is slightly disturbed, there are forces tending to return it to parallelism, and at the same time giving the whole system all the effects of gyroscopic motion, but of a peculiarly modified character arising from the flexibility of the rings of the electrons. The methods of extending the calculations to rings of many electrons are dealt with.

For three atoms in a molecule there are shown to be at least two stable positions differing in degree of stability, and one case is calculated with four atoms in the molecule. This might represent a ring of three hydrogen atoms with one nitrogen atom at the apex of the right cone of which the ring forms the base. The addition of another atom increases considerably the distances necessary for equilibrium, and a case calculated might represent carbon with a ring of four hydrogen atoms. If nitrogen, oxygen, fluorine were successively substituted for carbon, the distances would increase for each substitution, so that the carbon compound would be the most stable, and the fluorine compound the least stable of the series. Even in the first case, however, the dimensions seem too great for the long-continued existence of the molecule, but if two of the hydrogen atoms are removed from the upper to the lower ring of the carbon atom, the distance between the carbon and hydrogen atoms is almost halved. The substitution of nitrogen for carbon in this case would give rise to methane, or marsh gas, with somewhat less stability.

The series obtained not being convergent does not give the force close to an atom, so as to show what becomes of a charge drawn towards an atom, thus forming an ion. The equations show, however, that it is false to assume that the charge in an atom has an effect equivalent to that of the same charge at the centre of the sphere; neutral atoms can, therefore, attract or repel, and it becomes unnecessary to assume the loss or gain of electrons by an atom in order to account for these actions. Moreover, with a Thomson atom, containing a small number only of electrons, the loss or gain of an electron could hardly be imagined as taking place without completely changing the character of the atom.

With respect to the possibility of accounting for gravitation by the electric forces the author points out that the only way as yet found to obtain terms with the inverse square of the distance is by the assumption of synchronous

revolution of the electrons at a great distance apart. The probabilities against such synchronous motions are very great, except at molecular distances, when a rigid connection has been established between the atoms of a molecule. It was found, however, that the orbital motions of the electrons must depart somewhat from circularity; and whether or not any terms may be found, due to the gyroscopic motions of the atoms, that will give rise to a force varying as the inverse square of the distance is worth investigating.

G. W. DE T.

1780. Spectroscopic Resolution of an Arbitrary Function. C. V. Burton. (Phys. Soc., Proc. 25. pp. 245-251; Discussion, pp. 251-252, June, 1918.)—An ordinary grating has periodic rulings, and a spectrum obtained by means of it is characteristic of the radiation entering the spectroscope slit. But if the radiation is homogeneous, while the distribution of the rulings is arbitrary, we obtain a spectrum characteristic of the grating. It is thus found to be theoretically possible to resolve spectroscopically a given arbitrary function into its harmonic constituents. The "permeability" of a photographic negative at any point being defined as the square root of the reciprocal of the "density," the first step is to make an "equivalent grating." This is a plate whose permeability (variable in one dimension only) has at any point x the value $A + B\phi(x)$, where A and B are constants. When this (transmission) grating takes its place in a spectroscope whose slit is fed with homogeneous light, the spectrum of the function $\phi(x)$ can be seen or photographed. Suitably interpreted, it gives us the periodogram of $\phi(x)$. A device is described which, it is hoped, may prove useful for determining the phases of the various harmonic constituents. The theory of the proposed method of resolving functions is discussed, and is as complete as that of ordinary spectroscopy, while in one respect it is more simple; for, since the light entering the spectroscope slit is entirely of one wave-length, the comparison of intensities of spectral lines (whether visually or photographically) is facilitated. Some preliminary practical tests are now being made. In the *discussion*, the author stated that he thought Rayleigh's method [Abstract No. 1868 (1908)] had great advantages. Also (in reply to Sears) that the present method gave the periodogram of a function as it was given by Fourier's double integral theorem, and, in analysing a column of numerical values, the method would give all the detail that was actually involved in the figures themselves. Eagle made reference to the analysis of a function extending over a limited range into the ordinary Fourier's series, pointing out that it would be necessary to repeat this function end to end a very large number of times in the grating.

A. W.

1781. Isostasy in the Alps. A. Prey. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2467-2518, Dec., 1912.)—A long discussion is given of the gravitational distribution, based on observations in the Tyrol, with tabular summaries of the densities and widths at eighteen selected longitudes, and groupings of the formations with their mean elevations.

C. P. B.

1782. Suspension of Particles in Air Eddies. W. Schmidt. (Meteorolog. Zeitschr. 80. pp. 171-174, April, 1918.)—Small particles under the action of gravity fall through still air with a velocity which does not exceed a value that is determined from Stokes' formula. If the air is rotating uniformly like a solid about an horizontal axis, the motion of a falling particle relative to the air is such that its direction of motion changes uniformly, i.e. the relative path is a circle. The time taken in describing the circle is equal

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to the time of a complete revolution of the air, and it thus follows that the *actual path* of the particle is a circle with its centre at a point distant horizontally from the centre of the vortex by an amount equal to the radius of the *relative path*. In consequence of the vortex motion the particle though continually falling with regard to the adjacent air, is in this way kept continually within the vortex, provided the latter does not change in position or intensity beyond certain limits. This is adduced as a possible explanation of the retention in the air of the small droplets of water which form clouds and also of the growth of successive layers of ice around hail-stones, it being considered that the growth takes place during the time that the newly formed stone is retained within the boundary of a vortex of air of suitable intensity.

R. C.

1783. *Theoretical Computation of Temperature-distribution in the Free Atmosphere on Occasions of Föhn.* F. Pockels. (Meteorolog. Zeitschr. 80. pp. 216-222, May, 1918.)—This is a mathematical discussion of the form of stream-lines over obstacles of suitable mathematical shape which are not dissimilar in their main outlines to mountains; and a computation of the rate of fall of temperature over different portions of the obstacles. An interesting result is that the deflection of the stream-lines in the air flowing over an obstacle is not confined to the lowest layers, but extends upwards to very considerable heights.

R. C.

1784. *Simultaneous Interdiurnal Changes of Pressure and Temperature on the Sonnblick and at Salzburg, with Remarks on Aperiodic Fluctuations of Pressure.* J. v. Hann. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 45-186, Jan., 1918.)—Salzburg lies about due north of Sonnblick at a distance of 88 km. The heights above sea-level are respectively 481 m. and 8105 m. Since changes of weather usually come from the west they affect both places nearly simultaneously, so that on the average the horizontal distance between the stations may be disregarded and they may be supposed to be in vertical line as regards changes of pressure and temperature. The mean change of pressure from one day to the next (interdiurnal variation), may be expressed by computing the means of the positive and negative changes separately. On the Sonnblick both of these quantities are about $2\frac{1}{4}$ mm.; the negative being slightly larger than the positive. At Salzburg the quantities are about $8\frac{1}{4}$ mm. The ratio between the values for the two stations agrees well with the theoretically computed ratio. For temperature the corresponding interdiurnal changes are on the mean for the year 2.54° C. for the Sonnblick and 2.88° C. for Salzburg. In 62 % of the total number of cases agreement is noted between the signs of the interdiurnal temperature-changes at the two stations. The percentage frequency of pressure-changes of like sign is 72 %. An examination is made of the 28 % of cases where the pressure variations are of opposite sign, and it is seen that when an increase of pressure at the summit synchronises with a decrease at the base the temperature of the whole column is rising; on the other hand, when the pressure is decreasing above and increasing below the temperature of the whole column of air is falling. A striking table shows that during the course of an increase of pressure extending over 2 or 3 days, temperature on the Sonnblick rises 1.40° C. on the first day on the average and as much as 2.2° C. on the second day; conversely a continuous fall of pressure is associated with a temperature fall of -2.1° C. on the Sonnblick during the first day and -2.9° C. during the second day. At Salzburg a pressure-increase or -decrease

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is associated with a fall or rise of temperature respectively on the first day, as may be expected, while the temperature-changes on the second day are irregular. Falls of temperature in connection with line-squalls and thunderstorms frequently extend to the *Sonnblick* but with diminished intensity. The author combats the old generalisation that the barometer falls below a warm column of air and rises below a cold one, maintaining that temperature variations in the upper air follow the pressure variations so that the latter are probably the cause of the former. He also points out the great differences between the ratios of monthly variations of temperature and pressure in different parts of the globe. If pressure-changes depend only upon temperature-changes that ratio should be nearly constant, whereas it varies both with latitude generally and also with distance from the sea. The origin of cyclones and anticyclones is looked for in connection with disturbances in the great atmospheric currents rather than in the appearance of warm or cold masses of air in the higher layers. R. C.

1785. *Motion of Cirrus Clouds in Relation to the Movements of Barometric Minima.* T. Hesselberg. (Beitr. zur. Physik d. freien Atmosphäre, vol. 5. No. 8. Meteorolog. Zeitschr. 80. pp. 895-897, Aug., 1918. Abstract.)—A comparison between the paths of cyclones and the direction of motion of cirrus clouds shows that at any instant the two directions of propagation are very nearly the same. The ratio between the velocities of the barometric minimum and of cirrus clouds varies from 0.8 to 0.6 according as the pressure at the centre of the depression is very low or not, and it remains constant provided that this pressure does not vary. If the cyclone is becoming deeper the ratio varies from 0 to 0.2; it is larger than 0.6 if the depression is filling up. The direction of motion of cirrus cloud changes very slowly with the lapse of time, consequently it is possible to predict the direction of motion of a depression for 12 to 24 hours in advance from an observation of the direction of cirrus. R. C.

1786. *Studies on Line-squalls among Mountains.* A. Roschkott. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2685-2686, Dec., 1912.)—Observations for these studies were derived from Innsbruck, situated in the valley of the Inn, and a number of stations on the surrounding Alps culminating with the mountain observatory on the Zugspitze (2964 m.). A comparison of barometer observations at the base and summit with the temperature observations at the stations on the mountain-side, show that before a squall the temperature of the free air over the valley is lower than that deduced from the observations at the stations. The surfaces of equal temperature therefore sink down from the mountain over the valley. After a squall the temperature-difference is much smaller and the surfaces of equal temperature are nearly horizontal. The lower layers are in unstable equilibrium before the squall; afterwards they are in stable equilibrium, and the sudden increase of pressure at the surface, characteristic of a line-squall, is explained by the replacement of the unstable layers of air by a current of cold air which pushes beneath them. A computation gives the mean depth of the cold current over Innsbruck from the amount of pressure-increase as 870 m. Specific humidity in the surface layers increases after the passage of the squall. If the squall is accompanied by rain, specific humidity decreases in the upper layers after its passage, because part of the moisture falls out of the air in the form of rain. If unaccompanied by rain the passage effects an increase of specific humidity in the upper layers also. R. C.

1787. *Results of Observations of Temperature and Pressure in Baroma.* J. Fényi. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2068-2078, Nov., 1912).—Baroma is in South Africa on the south side of the Zambesi, about 800 miles from the Indian Ocean. Tables of hourly means (4 years) of temperature, frequency of temperature, and harmonic coefficients of diurnal variation of pressure and temperature in the different months of the year are given in detail, and the results are discussed. The observations were obtained from a small Richard thermograph and a Richard barograph, both of which were periodically set to agree with standards. R. C.

1788. *Results of Pilot Balloon Ascents at Vienna in Anticyclonic Weather.* R. Dietzius. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2081-2117, Dec., 1912).—The paper is based upon observations of 48 pilot balloons, each of which was followed to a height of at least 8000 m. The direction and magnitude of the barometric gradient is determined for each occasion from pressure observations made at the corners of a triangle which contained Vienna. Taking the ascents collectively, the mean angle between the wind in each $\frac{1}{4}$ km. of height and the direction of the gradient is computed, the mean wind being obtained vectorially from the single observations. Finally the weather conditions which determine a right-handed or left-handed change of direction of the wind from 1500 m. to 8000 m. are examined. The change in direction is found to be connected in general with the direction of motion of barometric minima. R. C.

1789. *The Distribution in Height of Penetrating Atmospheric Radiation.* E. Schrödinger. (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2391-2406, Dec., 1912).—The sources of the radiation are divided into three: (1) materials contained in the earth or precipitated upon its surface; (2) radio-active substances suspended in the air; (3) hypothetical cosmical sources. The last is introduced in case it is found that the first two are insufficient to account for the observed phenomena. The first source has been investigated quantitatively by Eve and King [Abstracts Nos. 862 and 864 (1912)], but the second has not hitherto been treated in this way owing to the lack of observations made in the free air. By a mathematical process it is concluded that the radiations from the earth and the air are probably of the same order of magnitude, although the former appears to exceed the latter. R. C.

1790. *Diminution of Solar Radiation in the Summer and Autumn of 1912.* A. Schedler. (Meteorolog. Zeitschr. 80. pp. 198-194, April, 1918).—In order to compare the transparency of the sky to solar radiation in 1911 and 1912, all those sunshine records obtained at Innsbruck from a Campbell-Stokes sunshine recorder, which showed a continuous burn from morning to evening, were selected, and the times at which the burns commenced were plotted on squared paper as ordinates against the corresponding days of year as abscissæ, and successive points joined. Two curves, one for each year, were thus obtained, and a comparison between them shows that on clear days in 1912 the sun commenced recording from 20 to 40 mins. later than it did at the corresponding time for 1911 on most of the days from the end of June to the beginning of Nov. A similar result, but in the opposite sense, is shown by the corresponding curves for the times of cessation of the burns on clear days. Before June and after Nov. the curves for 1912 approximate to those of 1911. This indicates that the transparency of the sky during the summer and autumn of 1912 was less than that of 1911. R. C.

1791. *Diminution of Solar Radiation at Warsaw during 1912.* L. Gorczyński. (Comptes Rendus, 157, pp. 84-86, July 7, 1913.)—Continuous registration of solar radiation by an electrical compensating instrument has been made at Warsaw since Jan., 1901, and mean values of radiation for each month since that date have been computed therefrom in gm.-cals./cm.² min.). These are represented in a table by means of differences from the means for the months. The diminution of radiation in 1912 is compared with that of 1902-1903. On the latter occasion radiation was continuously below the average from Nov., 1902, to Oct., 1903; on the former occasion the diminution of radiation extended from July, 1912, to Jan., 1913; the largest divergence from normal being in the month of September.

R. C.

1792. *Amount of Annual Evaporation from Swiss Lakes.* J. Maurer. (Meteorolog. Zeitschr. 30, pp. 209-218, May, 1918.)—A brief description is given of the direct hydrometric method of computing the amount of evaporation from large lakes, with especial reference to observations carried on in connection with the Zügersee (area 88 km.²) and the Ägersee (area 7 km.²) during 1912. The method consists in making simultaneous measurements of (1) lake level, (2) rate of flow of water from and to the lake, (3) cross-sections of out- and in-flows, (4) rainfall since last observation. The amount of water collected as rain and from inflowing streams is then computed, and the amount carried away by streams, corrected for variation in the level of the lake, will differ from it by the amount of water evaporated. The method is simple in theory but not easy in practice. The results for the year Dec., 1911, to Nov., 1912, give an evaporation of 775 mm. from the Zügersee and 740 mm. from the Ägersee, with maximum in July and minimum in Dec. On account of the rainy character of the season the amount is below the average, which is probably about 900 mm.

R. C.

1793. *Observations on Ocean Temperatures in the Vicinity of Icebergs and in other Parts of the Ocean.* C. W. Waidner, H. C. Dickinson, and J. J. Crowe. (Washington Acad. Sci., Journ. 8, pp. 405-412, Sept., 1918.)—These observations were undertaken, by courtesy of the U.S. Navy Dept., with a view to obtaining information on the possibility of detecting the proximity of ice from temperature-records. Some of the more important apparatus used consisted of the following: (1) A surface electrical resistance thermometer, made up of a flat coil of silk-covered nickel wire enclosed between copper sheets and insulated by thin layers of mica. The resistance of the nickel coil was about 100 ohms. (2) Deep-sea thermometers of the Negretti and Zambra type. (3) Several standard mercurial thermometers. (4) A Leeds and Northrup recorder suitable for use with the resistance thermometers. The surface thermometer was mounted with its flat face directly against the inner surface of the ship's $\frac{3}{8}$ -in. plates, about 6 ft. below the water-line. Simultaneous measurements of temperature, made with a sensitive mercurial thermometer inserted in the water and with the surface thermometer and recorder, showed that sudden changes in sea-water temperature were indicated by the recorder without any significant time-lag. Practically continuous temperature records were obtained from June 4 to July 10, 1912, and the temperatures ranged from 8° to 25° C. Also variations in the salinity of sea-water in the neighbourhood of icebergs, due to the diluting action of the water resulting from the melting of the ice, were found to be so small as to be entirely masked by the accidental variations found in sea-water. The testimony of numerous observers is on evidence that the echo of the fog-horn may frequently, but by no means always, be detected when in the proximity

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of an iceberg or even of a bank of fog. The experiment of sounding the fog-horn was tried, but in no instance could an echo be detected, while similar experiments to determine whether an echo occurred under water from the larger, submerged portion of the berg were very inconclusive. Other experiments were tried, such as firing 8- and 5-in. shells into the berg, the utility of searchlights in locating bergs at night, etc., but the results were most disappointing. Samples of ice broken from the berg by gun-fire were found to contain considerable amounts of included air, which probably accounts for the white appearance. The water resulting from the melting of the iceberg was found to have the same density as that of distilled water, being also free from any characteristic taste. So far as the observations went, the temperature of the air furnished no evidence of value as to the proximity of a berg. From a study of the temperature records, the difficulty of separating the large and sudden variations of sea-water temperature, so frequently met with, from any variations that may be caused by the proximity of icebergs proved insuperable. It follows, therefore, that it is practically impossible to draw definite conclusions as to the proximity of ice from temperature records. Curves are drawn to illustrate the temperatures about icebergs. In general there was a fall in temperature of about 1 deg. in 4 or 5 miles in approaching the various bergs, although positive-conclusions as to the absence or proximity of ice cannot be made from the records. The authors state, however, that this is not a condemnation of the use of suitable recorders on ships, as such may give valuable information on the approach to shore and shallow water and the identification of characteristic ocean currents. They also state that if the "characteristic iceberg effect" observed by Barnes, *i.e.* rise of temperature on approaching icebergs [Abstract No. 1019 (1912)], had been present round the bergs observed by them, either of the same or even much less magnitude, the records would have rendered such an effect evident, notwithstanding the irregular variations of temperature usually found to exist. In view of the differences in the character of the two records the authors feel it to be very desirable that further observations be made in different parts of the ocean and under varied conditions before attempting to draw final conclusions.

H. H. Ho.

1794. Radium in Chromosphere. S. A. Mitchell. (Popular Astronomy, June, 1918. Observatory, No. 468. p. 807, July, 1918.)—The spectrum of the chromosphere obtained in 1901 seemed to show that neon and argon were present, but the evidence was inconclusive. Examinations of the better photographs obtained in 1905 have furnished better measures for comparison with the laboratory wave-lengths of the spectra of radium, neon, argon, krypton, and xenon. No coincidences of sufficient certainty have been found to favour the view that these elements are present in the chromosphere. [See Abstract No. 40 (1918).]

C. P. B.

1795. Diminution of Solar Mass by Radiation. J. Bosler. (Le Radium, 10. pp. 168-170, May, 1918.)—An attempt is made to calculate the amount of the diminution of the solar mass in consequence of radiation. Taking 2.5 as the solar constant, it is found that the sun would lose a mass equivalent to that of the earth, 6×10^{27} gm., in a period of 80 million years.

C. P. B.

1796. Harmonic Analysis of Relative Sun-spot Numbers. H. Kimura. (Mathematico-Physical. Soc., Tokyo, Proc. 7. pp. 71-85, April, 1918. Roy. Astronom. Soc., M.N. 78. pp. 543-548, May, 1918.)—The investigation of the variation of sun-spot numbers was undertaken in connection with the dis-

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cussion of variations of the earth's pole. It is found that the 11-year period is not so conspicuous as is generally supposed, although it has the largest amplitude; its length is nearer to $11\frac{1}{2}$ years than to $11\frac{1}{4}$. Many subsidiary periodicities lie between 8 and 12 years. Of the long periods, besides Wolf's 81-year cycle, a definite period of 54 years is detected. C. P. B.

1797. *Theory of Gaseous Solar Photosphere*. Gouy. (Comptes Rendus, 156. pp. 852-855, March 17, 1918.)—Working on the hypothesis of a gaseous photosphere, several of the principal actual phenomena are compared with those developed by the application of the theory, on the assumption that the radiation is entirely thermal, and that it obeys Kirchhoff's law. C. P. B.

1798. *Temperature of Moon*. F. W. Very. (Science, 87. pp. 949-957, June 20, 1918.)—The author refers to a joint memoir by Langley and himself, published in 1889, wherein the surface temperature of the moon is given as $+45^{\circ}$ C. Langley was apparently unwilling to accept unreservedly such a high value compared with the older estimates; a discussion of the conditions under which the comparisons were made tends rather to make the estimate of lunar temperature go still higher, the later measures assigning a temperature of about 454° C. (abs.) to the lunar subsolar point. C. P. B.

1799. *Evidence for Lunar Atmosphere*. M. E. J. Gheury. (Observatory, No. 462. pp. 268-269, June, 1918.)—Observing the occultation of π Scorpii (mag. 8.1) on April 22, 1918, with a $8\frac{1}{4}$ -in. Wray refractor at Eltham, a faint star was seen before the appearance of the much brighter star identified as the one expected. As π Scorpii is not a close double, the appearance is attributed to refraction by the lunar atmosphere. C. P. B.

1800. *Neptune's Faint Equatorial Belts*. T. J. J. See. (Astronom. Nachr. No. 4656. Nature, 91. p. 407, June 19, 1918. Abstract.)—The paper gives a summary of some old observations made with the 26-in. refractor at the U.S. Naval Observatory at Washington in 1899-1900. Beaded bands or belts were faintly visible against the brighter body of the planet. C. P. B.

1801. *Origin of Planets and Satellites*. K. Birkeland. (Archives des Sciences, 85. pp. 529-564, June, 1918.)—An amplified version of the paper dealt with in Abstract No. 868 (1918), with the addition of several photographs of the discharges obtained. L. H. W.

1802. *Spectrum of Comet Schaumasse (1918a)*. J. Bosler. (Comptes Rendus, 156. pp. 1658-1654, June 2, 1918.)—Successful photographs of the spectrum of Comet Schaumasse (1918a) were obtained during May, 1918, with exposures varying from 1h. 50m. to 8h. 20m. Three bands are visible on the plates, near wave-lengths 888, 404, 478. C. P. B.

1803. *Photometric Observations of Zodiacal Light*. Fessenkoff. (Comptes Rendus, 157. pp. 196-198, July 21, 1918.)—Observations of the zodiacal light have been made with an astrophotometer, during Feb. and March, 1918, at Meudon, and during April and May at Nice. The instrument was kept at the same altitude to avoid errors due to variable atmospheric absorption. The results are tabulated showing the position of the axis of the zodiacal light with respect to the angular distance of the sun along ecliptic. C. P. B.

1804. *Solar Eclipse Expedition to Vavau, Tonga Islands, April 29, 1911*. W. J. S. Lockyer. (Solar Physics Committee Report. [82 pp.] London, 1912.)

LIGHT.

1805. Spectrophotometer for Ultra-violet. F. P. Defregger. (Ann. d. Physik, 41. 5. pp. 1012-1055, Aug. 5, 1918.)—A paper dealing with a spectrophotometer for ultra-violet light, originally designed by H. T. Simon [Ann. d. Physik, 59. p. 61, 1896]. A series of tests showed various defects, which have been in part remedied by modifications of construction. A method is described of securing uniform illumination of the slit for the lens combinations employed. A description is also given of an improved comparator for evaluating the photographic records, which possesses high sensitiveness and is independent of the uniformity of movement of the plate. Possible errors are discussed at length, and experimental tests are described. Proposals are made for an improved construction of the apparatus. A. W.

1806. Method of Testing Optical Reflectors. J. Rey. (Comptes Rendus, 157. pp. 829-831, Aug. 4, 1918.)—The method dealt with is applicable to parabolic reflectors, and can easily be extended to reflectors of hyperbolic or elliptical form. The reflector under test is mounted on an optical bank, its axis being parallel to the length of the bank. At a little distance from the reflector is placed a vertical frame carrying a rectangular grid with square meshes, made by two sets of wires tightly stretched. A metre behind the frame is placed vertically a ground-glass screen. Using a very small arc as the source of light on the axis of the reflector, a shadow image of the square meshes may be obtained on the screen, being due to the light reflected from the parabolic mirror. If the surface is exactly parabolic, the shadow image of the grid is the same as the grid itself, and consists of straight lines perpendicular to one another. If the shadow image shows curved lines, the surface of the reflector is not parabolic; it is easy to see what parts of the surface have incorrect curvature, and measurements of the error of position of points of the shadow image serve to determine the amount of error in the corresponding part of the reflector. A. W.

1807. Apparatus for Investigating the Double Refraction of Optical Glass. H. Schulz. (Zeitschr. Instrumentenk. 88. pp. 205-209, July, and pp. 247-258, Aug., 1918.)—Gives further details of the instrument previously described [Abstract No. 888 (1918)], with photographs and diagrams relating to various samples of glass that have been tested with the apparatus. Most of the glasses dealt with show negative double refraction under pressure, but a specimen of flint glass showed positive double refraction. This is of interest, since up to the present positive double refraction under pressure has only been observed with fluorspar and sylvia for certain pressure-directions. A. W.

1808. Abbe Focometer. H. Fassbender. (Zeitschr. Instrumentenk. 88. pp. 210-218, July, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—A paper describing a method of determining, by means of the Abbe focometer, in what way the positions of the principal planes of a lens system depend on the zone of the lens employed and on the wave-length of the light. [See also Abstract No. 2861 (1904).] A. W.

1809. *Index of Refraction of Liquid Hydrogen*. W. Meissner. (Deutsch. Phys. Gesell., Verh. 15. 18. pp. 540-554, July 15, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—A description is first given, with diagram and photographs, of the plant used for the liquefaction of hydrogen. A total reflection method, using a pair of parallel plates with a gas film between, was employed for determining the index of refraction of the liquid hydrogen. Applying Cuthbertson's measurements to Planck's dispersion formula, the refractive indices for several wave-lengths are calculated, and, as is seen from the following table, agree well with the observed results.

λ	I. ν (obs.).	II. ν (calc.).	I.—II.
0.656 μ	1.1119	1.1102	0.0017
0.689 μ	1.1117	1.1107	0.0010
0.492 μ	1.1122	1.1118	— 0.0004

A. W.

1810. *Diffraction Phenomena: Superposed Fringes*. C. F. Brush. (Amer. Philosoph. Soc., Proc. 52. pp. 276-282, April, 1918. Paper read before the Amer. Assoc. for Advancement of Science, Dec., 1912.)—The author has found that when diffraction fringes are observed within a mm. or two of the diffracting edge, by means of a microscope, they are very greatly influenced in brightness and sharpness by the contour of the edge. Cylindrical edges were used in most of the experiments, ranging from fine wires of 0.02 mm. diam. up to large brass rods and tubes, always with a smooth surface. The fine wires and needles were screened on one side to confine diffraction to the other side only. The fringes projected by the edge of a sharp razor-blade are weak, few in number and hazy in outline. With a fine wire the fringes are distinctly better. Every time the radius of the cylindrical edge is doubled, the fringes are unmistakably brighter and sharper. Various considerations tend to the conclusion that the very greatly enhanced brightness of the fringes produced by the diffracting edge of large radius as compared with the razor-edge, is due to the superposition of a number of diffraction image patterns which are almost, but not quite, in register. With two razor-blades clamped together with their edges as close as possible (about 0.2 mm.), and as nearly as possible in the same plane, the brightness of the one-blade fringes is approximately doubled, if the combination is rotated slightly about the line of one of the edges, so that the edge nearer the slit may be withdrawn very slightly below the plane of the incident beam which strikes the other edge. It appears that twice as many elements of each wave-front are affected. We may regard the cylindrical diffracting surfaces as consisting of a great many parallel elements, each acting as a diffracting edge and producing its own fringe pattern which is superposed on those of the other elements. Using a glass plate with polished surface 12 mm. wide, Lloyd's so-called "single-mirror interference fringes" were brilliantly shown, the spacing being sensibly uniform and the fringes showing more and more colour from the third onwards. Experiments with an arrangement of 24 paper-thin razor-blades clamped together with the edges all in one plane showed that all the effects obtained with the mirror could be reproduced, differing only, and but little, in brilliancy. Hence it appears that the so-called "single-mirror interference fringes" are not due to interference of light reflected at grazing incidence with contiguous rays not reflected, as commonly supposed, but are superposed diffraction fringes.

A. W.

1811. *Fermat's Law*. D. N. Mallik. (Phil. Mag. 26. pp. 144-158, July, 1918. From Bull. of the Indian Assoc. for the Cultivation of Science.)—By critically examining Fermat's law of swiftest propagation of light $\delta f/dt = 0$, (where t is the time of propagation and δ is the operator of the calculus of variation) the author concludes that all optical energy is *entirely kinetic*. Hence he is led to infer that *all energy is kinetic*. The view is thus reached, through this optical law, that some subtle ethereal motion is associated with every given configuration of a conservative system existing in a field.

The bearing of this on other modern views is discussed.

E. H. B.

1812. *Interference Bands with Partially Silvered Plates, and Absorption Spectra in the near Infra-red*. A. H. Pfund. (Zeitschr. wiss. Phot. 12. pp. 841-856, Aug., 1918.)—From the research described it appears that interference bands produced by partially silvered plates can be utilised for dispersion measurements in the infra-red. Interference bands produced in the manner described are very sharp and have great intensity. The absorption spectra of several aniline dyes were obtained in the region 0.55μ , to 1.2μ ; and some excellent colour-filters for photography in the red and near infra-red were discovered. Colour glasses were investigated in a similar manner, and their inferiority as colour-filters demonstrated. The wave-lengths of the narrow absorption bands of neodymium nitrate and erbium chloride were also measured. The heads of the principal bands in the long-wave region lie approximately at 0.580μ , 0.780μ , 0.785μ and 0.868μ for the former substance, and at 0.649μ , 0.687μ , 0.797μ and 0.980μ for the latter.

A. W.

1813. *Total Radiation of Hefner Lamp*. W. Gerlach. (Phys. Zeitschr. 14. pp. 577-581, July 1, 1918.)—In order to provide a standard of total radiation, the author measured that of a Hefner lamp screened off by a diaphragm placed at 10 cm. from the flame and having a rectangular aperture 14×50 mm. Two different lamps and three makes of amylacetate were used. All showed the same value of the radiation, so long as the amylacetate was pure. The error of reproduction should not exceed 1.5 per cent. The value obtained by means of a thermopile is the same as that obtained by Ångström by means of a pyrheliometer. It amounts to 2.25×10^{-6} cal./cm.²/sec. at 1 m. This corresponds to a radiation constant of 5.90×10^{-12} watts/cm.²/deg.⁴/sec.

E. E. F.

1814. *Flicker Photometer and the Iris*. H. C. Stevens. (Phil. Mag. 26. pp. 180-188, July, 1918.)—Rayleigh [Abstract No. 898 (1918)] has suggested that the flicker sensation might be due to the iris diaphragm in the eye attempting to follow the changing illumination. The author has carried out experiments on two observers whose eyes had been treated with atropine so as to paralyse the muscle controlling the iris. In these circumstances the appearance of the flicker was not changed in any respect from what it was before the atropine was placed in the eyes, the intensity and frequency remaining the same. Some other explanation of the sensation of flicker must therefore be sought.

J. S. D.

1815. *On Magneto-optical Rotativity*. G. H. Livens. (Phil. Mag. 26. pp. 862-866, Aug., 1918.)—The author's modification of Drude's analysis of the electromagnetic theory of optics is here applied to the question of the additivity of the rotations of liquid mixtures. It would appear that a strict superposition of the rotations of solvent and solute can never take place.

L. H. W.

1816. *Flame Spectra of the Halogen Salts*. E. N. da C. Andrade. (Phys. Soc., Proc. 25. pp. 280-288; Discussion, p. 284, June, 1918.)—Wires of certain metals, if held in a chlorinated flame, give characteristic colourations in different zones of the flame. These are due to the chlorides of the metal. The chloride spectra of nickel, cobalt, and iron, also several bromide and iodide spectra have been examined. In the case of those metals, whose colouration of the flame is destroyed by chlorine, the vapours are not charged, while in the case of metallic chlorides which give characteristic spectra, the vapours are strongly charged. J. M.

1817. *Electric-furnace Spectrum of Iron*. A. S. King. (Astrophys. Journ. 87. pp. 289-291, May, 1918. Contribution from Mt. Wilson Solar Observatory, No. 66.)—Details are given of a long investigation of the variations with temperature of the electric-furnace spectrum of iron. This type appears to come between the flame and arc spectra. The experiments have been made with a carbon-tube resistance furnace, with which any desired steps of temperature can be measured, up to a point where the vaporisation of the carbon becomes excessive. Current varying from 800 to 1600 amps. was used at pressures from 15-30 volts given by a 50-kw. transformer. The observations of temperature were made with a Wanner pyrometer regularly during the operations. In a series of tables the relative intensities of iron lines in the visible spectrum are given for three furnace temperatures and for the arc, with a division into six classes based on the temperature at which a line appears in the furnace and its rate of growth with increase of temperature. The changes in relative intensities of lines observed in passing from the furnace spectrum to that of the arc may in general be accounted for by a difference in conditions equivalent to a large temperature-difference, though one class of furnace lines presents difficulties. The red end of the iron spectrum appears to require high temperature for its production as compared to the blue region, and the distribution of lines through the visible spectrum bears little resemblance to the intensity gradation observed for the spectrum of an incandescent solid. The ultra-violet region is very rich in lines given by the furnace. The extension of the line spectrum towards shorter wavelength with increase of temperature was observed, it being found that lower limits were reached for a given temperature by the spectrum of an incandescent solid. A list is given of pairs of lines whose members belong to different classes as regards response to temperature changes, and may be used in estimating the relative temperatures of light sources. The enhanced lines of iron in the visible region have not been observed in the furnace spectrum. [See also Abstract No. 1524 (1912).] C. P. B.

1818. *Absorption of Ultra-violet Rays*. V. Henri. (Phys. Zeitschr. 14. pp. 515-516, June 15, 1918.)—Describes a new quantitative method for determining the absorption due to a solute. The spectrum is photographed as transmitted by the solvent alone, say for t secs. Then it is photographed through the solution for various exposures t_1, t_2 , etc. Finally, those lines are found which give the same blackening in contiguous spectra. The intensities of light of a particular wave-length transmitted through the solvent (I) and the solution (I_1) respectively are given by $I/I_1 = (t_1/t)^n$, where n is a constant depending upon the make of plates. The author gives a series of 45 spectra of acetone solution alternating with water as a solvent. He also states that a strong continuous ultra-violet spectrum may be obtained by a Tesla discharge through water. The spark can be made 5 mm. long. E. E. F.

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1819. Absorption of Ultra-violet Rays by Acetone. J. Bielecki and V. Henri. (Phys. Zeitschr. 14. pp. 516-521, June 15, 1918.)—Acetone has a single absorption band in the ultra-violet. Its maximum in an alcoholic solution lies at $\lambda = 2706$, and in aqueous solution 2648. The Ketteler-Helmholtz formula, assuming one sort of electrons, gives a good rendering of the absorption curve over 500 Å.U. There is one electron for 86 molecules. Assuming that in organic molecules the frequencies of the electrons are variable and are distributed according to Gauss's law, the absorption can be represented by an exponential formula which fits most of the results, and which can be retained as an empirical formula even if the assumption should turn out to be incorrect. E. E. F.

1820. Band Spectra of Mercury. J. Stark and G. Wendt. (Phys. Zeitschr. 14. pp. 562-566, July 1, 1918.)—Mercury has at least two distinct band spectra. The first spectrum is obtained with pressures of Hg vapour amounting to 1 to 10 mm., and is radiated by the positive column, with current densities below 1 amp. per cm.². It has maxima of intensity at 490 to 400 $\mu\mu$, 850 to 810, 270 to 250, at 248, and at 284 $\mu\mu$. The second band spectrum is obtained when a greater power is consumed in the tube. It is identical with that previously studied by Eder and Valenta. There are indications of a third band spectrum emitted by the negative glow, but wanting in the positive column, and consisting each of a series of sharp lines. The authors incline to associate the first band spectrum with the formation of neutral ions each consisting of an electron and a monovalent Hg atom. The second band spectrum probably concerns bi- or tri-valent Hg atoms. E. E. F.

1821. Mercury Lines and Bands. J. Stark and G. Wendt. (Phys. Zeitschr. 14. pp. 567-568, July 1, 1918.)—This is a special study of the mercury lines 2536.7 and 2845.5, and their separation from the bands at 2540 and 2846. The first line is important as being the head of a series attributable to a neutral atom. It is shown, both by emission and absorption spectrograms, that there is no connection between the lines and the adjoining bands. E. E. F.

1822. Energy Distribution of the Long-wave Radiation of Mercury Vapour. H. Rubens and O. v. Baeyer. (Preuss. Akad. Wiss. Berlin, Ber. 88. pp. 802-809, 1918.)—In a previous paper [see Abstract No. 1447 (1918)] it was shown that the twofold division of the Reststrahlen by rock-salt, sylvin, and potassium bromide is brought about by the selective absorption of the water-vapour present in the air of the room in which the experiments were performed; also it was found that the presence of water-vapour in the path traversed by the rays modified considerably, in the spectral region employed, the long-wave radiation of the Auer burner isolated by a special arrangement of quartz lenses. In the present paper the influence of the selective absorption of water-vapour on the energy distribution of the long-wave radiation from mercury-vapour is dealt with. The mercury lamp used was of the same type as used in earlier work [Abstract No. 1678 (1911)]. The research shows that, so far as the water-vapour present in the air in the path of the rays is concerned, it has no appreciable effect on the energy distribution of the long-wave radiation; but if a sufficient amount of water-vapour is introduced into the apparatus, a marked variation of the energy distribution is produced. It also was found that water-vapour absorbs the short-wave part of the radiation much more strongly than the long-wave radiation. A. W.

1823. Spectra Developed by the Tetrachlorides of Silicon and Titanium. W. Jevons. (Roy. Soc., Proc. Ser. A. 89. pp. 187-198, Aug. 27, 1918.)—In previous papers Strutt and Fowler have given accounts of the spectrum of the afterglow of nitrogen, and of the spectra of various elements and compounds excited by the active modification of nitrogen [Abstract No. 677 (1912)]. The present paper gives an account of the spectra developed on the introduction of the vapours of SiCl_4 and TiCl_4 into the nitrogen afterglow. The SiCl_4 afterglow is notable for the occurrence of a new system of bands between $\lambda 8800$ and $\lambda 4950$, with heads degraded towards the red. The bands show intensity minima near the heads, corresponding to the modifications of the cyanogen afterglow bands. The wave-lengths of the heads have been determined, and their frequencies arranged into groups, similar to the classification of the cyanogen bands and the positive bands of nitrogen. The new bands do not occur in the discharge through SiCl_4 (which is characterised by a different system of bands) and are therefore attributed to a nitride of silicon. Chemical evidence in support of this has been obtained by Strutt. The TiCl_4 afterglow, however, develops no bands of a corresponding nitrogen compound of Ti. Its spectrum is merely that of the titanium arc, together with the group of flutings characteristic of TiCl_4 . A. W.

1824. Infra-red Absorption Spectra of Gases. W. Burmeister. (Deutsch. Phys. Gesell., Verh. 15. 14. pp. 580-612, July 30, 1918. Extract from Dissertation, Berlin.)—The light from a Nernst burner was passed through a Wadsworth mirror spectrometer and received finally on a microradiometer. The absorption tube could be introduced in the path of the light or removed at will and again fixed in exactly the same position by means of a pivoted arm to which it was rigidly secured. Various prisms, of fluorspar, rock-salt, and sylvia, permitted different ranges of wave-lengths to be dealt with, and the investigation of the absorption spectra was made in steps of 0.1μ from 1μ to 18μ and of 0.8μ from 18μ onwards. The maxima of the absorption bands investigated lie at the wave-lengths shown in the following table, double bands being given in brackets and wave-lengths in μ :—

Cl_2	—	H_2	—
Br_2	—	O_2	—
HCl	[8.40 ; 8.55]	HBr	[8.84 ; 4.01]
(CN)	[8.79 ; 8.98] ; 4.65 ; 18.50 ; 16.07		
HCN	8.04 ; [6.95 ; 7.22] ; [18.60 ; 14.88]		
C_2H_2	2.52 ; 8.07 ; 8.77 ; [7.89 ; 7.66] ; [18.50 ; 18.95]		
CO	2.85 ; [4.60 ; 4.72]	CO_2	[14.70 ; 15.05]

No researches up to the present have revealed any gaseous element having a measurable absorption band below 1μ . It is remarkable how many absorption bands are found to be double on sufficient investigation. HCl and HBr have both only one double band, that of HBr being distorted considerably on the side of the longer waves. CO_2 and CO show similar absorption only at 5μ . There is no analogue in the CO spectrum to the third CO_2 band. There is a marked similarity shown in the absorption spectra of such different gases as HCN and C_2H_2 . On the other hand (CN) , and HCN have no similar bands, although they possess the same ion (CN) . [See also Abstracts No. 1562 and 1868 (1909).] A. W.

1825. Measurement of Zeeman-effect. G. F. C. Searle. (Astrophys. Journ. 87. pp. 282-287, May, 1918.)—Purvis has drawn attention to the VOL. XVI.—A.—1918.

discrepancies between the values of the Zeeman-effect obtained by him in the case of certain lines in the spectrum of chromium, and the values obtained by Miller, Hartmann, and Babcock. [Abstract No. 148 (1912).] Purvis used a field of 89,980 c.g.s. Further discussion was provided by Cotton [Abstract No. 1198 (1912)]. Searle now states that he made the experiments giving the field strengths quoted by Purvis, and describes the precautions taken to avoid errors in the determinations. Since the first tests, however, defects due to overheating, etc., appear to have developed in the coil windings of the magnet, and a recent re-determination of the field given by 20 amps. gives the value 28,700 c.g.s., whereas in the measurements in 1903 the same exciting current gave a field of 89,700 c.g.s. Details are given of the constants of the exploring coil used in the new experiments.

C. P. B.

1826. *Anomalous Zeeman-effect of Spectral Lines of the D-type.* W. Voigt. (Ann. d. Physik, 42. 1. pp. 210-280, Aug. 26, 1918).—A continuation of previous work [Abstract No. 1441 (1918)] in which further treatment is given of the author's coupling theory of the Zeeman-effect observed with line systems of the D-type.

A. W.

1827. *Phosphorescence of Mercury-vapour after Removal of the Exciting Light.* F. S. Phillips. (Roy. Soc., Proc. Ser. A. 89. pp. 89-44, Aug. 1, 1918).—Wood has shown that light of wave-length 2586 produces resonant radiation in mercury-vapour even when the vapour has only the very small density corresponding to ordinary temperatures [Abstract No. 1182 (1912)]. Under these circumstances the exciting radiation could penetrate a distance of a few cm. into the vapour without total absorption taking place, but if the temperature was higher and the vapour consequently denser the radiation could only penetrate a few mm. Wood does not appear to have stated that this 2586 light produces visible fluorescence in mercury-vapour. This, however, is the case, and it is excited at a much lower pressure than when cadmium light is used. Experiments showed that there are apparently three distinct phenomena excited by 2586 light in mercury-vapour: (1) Resonant radiation, which exists over a long range of pressure from about 0.001 mm. to about 1 cm. (2) Ordinary fluorescence, which does not rapidly grow less bright as the beam passes through the vapour: this exists when the pressure of the mercury-vapour is about 1 cm. (3) Local fluorescence at the point of entrance of the beam: this exists at much lower pressures than the ordinary fluorescence, but not at the very low pressure corresponding to ordinary temperature. It is this local fluorescence that has been found to be persistent. A beam of the exciting light was passed across a moving column of vapour, obtained by distilling mercury in a long evacuated tube in the form of an inverted U. The exciting light of wave-length 2586 was obtained by means of a water-cooled silica lamp. When the light was passed across the moving column of vapour the fluorescence was carried along with the vapour for a distance of some 18 in. from the point of excitation. There appears to be some connection between the resonant radiation and the persistent fluorescence. Certain observations seem to show that about 1/20 of the secondary radiation in Wood's experiment was probably due to moving molecules. The rest would be produced by scattered light from the primary beam. Besides mercury, the vapours of such substances as iodine,

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anthracene, and retene were experimented with in order to ascertain whether the fluorescence of the vapours persisted, but no positive results were obtained. A. W.

1828. *Production of Röntgen Rays by Slowly-moving Electrons.* H. Dember. (Deutsch. Phys. Gesell., Verh. 15. 18. pp. 560-565, July 15, 1918.)—Electrons are produced by ultra-violet light from a potassium electrode in a vacuum tube. They are subjected to a weak electric field, and under the influence of this field they move towards an antikathode of Pt, where they generate Röntgen rays by their impact. The Röntgen rays are detected by allowing them to fall on a Pt plate connected to an electrometer. This plate is protected by a metal cylinder which is kept at a somewhat higher potential than the antikathode, the whole arrangement being so designed as to prevent electrons from reaching the Pt plate in the cylinder. It is found that Röntgen rays are not produced when the electric field in which the electrons move is less than 18.7 volts. The wave-length of the Röntgen rays produced with this field is calculated to be $74.5 \mu\mu$, which is near that of extreme ultra-violet radiation. It is pointed out that the corresponding frequency is very nearly the frequency of free vibration of the atom of gases [see Abstract No. 862 (1910)], and that therefore the cessation of production of Röntgen rays with an applied field of 18 volts may be due to absorption of the radiation in the gas film on the antikathode. [See also Abstract No. 1892 (1911).] T. P. B.

1829. *Passage of X-rays through Metals.* E. Hupka. (Phys. Zeitschr. 14. p. 623, July 15, 1918.)—When X-rays are transmitted through Pt-foil of 0.01 mm. thickness, the impression on a photographic plate is not a simple patch with hazy outline, but a patch surrounded by radial stripes, which become irregular points on annealing the metal. Gold shows the same effect somewhat feebler, but not iron or Al. The author attributes this effect to microcrystals in the Pt and Au. Some of the photographs are reproduced.

E. E. F.

1830. *Reflection of X-rays by Crystals.* W. H. Bragg and W. L. Bragg. (Roy. Soc., Proc. Ser. A. 88. pp. 428-488, July 1, 1918.)—In the discussion of the Laue photographs it has been shown that they may conveniently be interpreted as due to the reflection of X-rays in such planes within the crystal as are rich in atoms [Abstract No. 604 (1918), etc.]. This leads at once to the attempt to use cleavage planes as mirrors, and it has been found that mica gives from its cleavage plane a reflected pencil strong enough to make a visible impression on a photographic plate in a few minutes' exposure. The present paper deals with the reflection of a beam of X-rays by the cleavage faces of various crystals, an ionisation method, using SO_2 , being employed to measure the strength of the reflected rays. The apparatus corresponds to a spectrometer, the parallel planes in which the atoms of the crystal are arranged taking the place of the lines of a grating, and the ionisation chamber that of the telescope. A fine slit in front of the X-ray bulb allows a beam of rays to fall on the face of the crystal, and both crystal and ionisation chamber turn about the axis of the instrument and can be set at any desired angles. By this method the authors have found evidence of the existence of three very homogeneous components in the rays from the bulb employed which are only reflected from the crystal at definite angles. They show as a very strong reflection "peaks" superimposed on the general reflection which takes place at all angles. Each of these has a definite absorption

coefficient in Al, and can be recognised when reflected from many crystals. One of the sets of homogeneous rays appears to correspond to that found by Chapman for the characteristic radiation of Pt (the antikathode was Pt). Thus rays of definite quality are reflected from a crystal when, and only when, the crystal is set at the right angle, this angle θ being given by $n\lambda = 2d \sin \theta$, in which λ is the wave-length of the rays used, d the distance apart of the planes of atoms in the crystal, and n is any small integer. The wave-length of one of the sets of rays is thus estimated to be 0.89×10^{-8} cm. Since the reflection angle of each set of rays is, as the experiments show, sharply defined, the waves must occur in trains of great length. A succession of irregularly spaced pulses could not give the observed effect. In the application of electromagnetic theory to monochromatic light on the one hand, and to homogeneous X-rays on the other, there is no difference to be considered beyond that of wave-length. The authors consider, however, that the results do not affect the use of the corpuscular or "entity" theory of X-rays. E. M.

1831. *Spectrum of Röntgen Rays*. J. Herweg. (Deutsch. Phys. Gesell., Verh. 15. 18. pp. 555-556, July 15, 1918.)—Using a soft X-ray bulb and a gypsum plate, the author has obtained photographically an X-ray spectrum similar to that obtained by W. H. and W. L. Bragg [see preceding Abstract]. The experiments were made with angles of 8° to 12° with the face of the crystal. With suitable dispositions the photographs showed three sharp dark lines on a continuous background. To avoid any "blurring" of the image due to a shift of the point of impact of the kathode rays the X-ray bulb was rotated so that the X-rays used consisted of a pencil almost glancing along the plane of the antikathode. E. M.

1832. *X-rays and Crystals*. W. H. Bragg. (Nature, 91. p. 477, July 10, 1918.)—In continuation of previous work [see Abstract No. 1880 (1918)] the author finds that an X-ray bulb having a rhodium antikathode gives off a strong, sharply defined (and therefore very homogeneous) beam which is reflected from the (1.0.0) face of rock-salt at a glancing angle of 6.2° . Its mass absorption coefficient in Al is 8.2. A second, weaker beam is reflected at an angle of 5.8° , and this appears to complete the rhodium X-spectrum. The wave-lengths of these beams are calculated to be 0.61×10^{-8} and 0.57×10^{-8} cm. respectively. The various experiments show that Pt and Rh give much stronger homogeneous reflected rays than Ir, W, or Ni. E. M.

1833. *Reflection of X-rays*. H. G. J. Moseley and C. G. Darwin. (Phil. Mag. 26. pp. 210-232, July, 1918.)—X-rays "reflected" from crystals have the general properties of ordinary X-rays. The radiation from an X-ray tube with a Pt target is of two kinds: (A) radiation of indefinite wave-length, analogous to white light; (B) five types of monochromatic radiation, probably characteristic of the Pt. The radiation (A) is reflected at all angles of incidence, but the reflection coefficient is small, certainly not greater than 0.005 for mica at the most favourable incidence, and rather less than that for selenite and potassium ferrocyanide, for which the most favourable incidence is $1\frac{1}{2}^\circ$ and $1\frac{1}{4}^\circ$ respectively. Each of the radiations (B) is reflected only at special angles, consistent with the simple theory of interference. The wave-lengths are 1.642, 1.897, 1.875, 1.194, and $1.167 \times K^{\frac{1}{2}} \times 10^{-8}$ cm., where K is probably either 1, $\frac{1}{2}$, or $\frac{1}{3}$. In rock-salt the angles of spiral reflection from VOL. XVI.—A.—1918.

the cube face range from $18^{\circ} 81'$ to $9^{\circ} 29'$. The authors have examined the homogeneity of the radiations and attempted to estimate the distribution of energy in the wave-lengths for the general X-rays. E. E. F.

1834. Form of X-ray Interference Patterns. M. Laue and F. Tank. (Ann. d. Physik, 41. 5. pp. 1008-1011, Aug. 5, 1918.)—In the Friedrich and Knipping photographs [Abstract No. 1158 (1918)] the spots corresponding to the max. effects are always elongated, the greatest length being perpendicular to the radius vector from the central image to the spot. This is most marked in the pattern due to zinc sulphide. The authors have found similar effects with various crystals so long as the distance between the crystal and the antikathode is small, but the effect becomes less marked as this distance is increased, until with 150 cm. distance it is not shown at all. The elongated shape of the spots is thus traced to the curvature of the wave surface as it reaches the crystal, and the authors modify the general theory to take this into account. The theory also brings out that the elongated form of pattern will arise whenever the rays traverse the crystal in a direction parallel to a principal crystallographic axis. The authors also discuss the absence of temperature effect on the interference patterns in the light of the assumption that the crystal consists of a large number of independent elements each having about 7.5×10^8 atoms. [See also Bragg, Abstract No. 999 (1918).] E. M.

1835. X-rays and Crystals. W. H. Bragg. (Engineering, 96. pp. 422-428, Sept. 26, 1918. Paper read before the British Assoc., Birmingham, Sept., 1918.)—[See Abstracts Nos. 1880 and 1882 (1918).]

1836. Nature of X-rays. C. G. Barkla. (Engineering, 96. p. 422, Sept. 26, 1918. Paper read before the British Assoc. at Birmingham.)—The evidence in favour of the electromagnetic wave theory of X-rays is first reviewed. Passing to characteristic (fluorescent) X-radiation, the author states that it is homogeneous and characteristic of the element which emits it; the intensity varies with that of the primary, inasmuch as the characteristic rays are not excited by softer rays. As measured by the ionising power the intensity of the characteristic rays shows that they do not carry away all the energy used up in their production, so that the total ionising power of the primary and secondary radiations is smaller than the original energy. Turning to corpuscular radiations, the author states that a substance exposed to X-rays emits electrons whose velocity depends on the penetrating power of the primary radiation, short waves giving high velocities, the energy being proportional to the frequency. The corpuscles carry all the ionising power, but not all the energy. The preponderating distribution is at right angles to the direction of propagation, but more corpuscles are hurled out on the emergent side than on the incident side, as in the case of ultra-violet light. Whatever the intensity of the radiation of a given type, corpuscles are ejected by it with the same velocity. This seems inexplicable at present. E. M.

1837. Decrease in Velocity of α -Particles in Passing through Matter. E. Marsden and T. S. Taylor. (Roy. Soc., Proc. Ser. A. 88. pp. 448-454, July 1, 1918.)—It is becoming recognised that one of the most fruitful sources of information as to the internal structure of atoms is provided by the phenomena attending the passage of swift electrified particles through them [Abstract No. 1847 (1911)]. Darwen [Abstract No. 1706 (1912)] and Bohr attempted to obtain information as to the number and distribution of electrons

in the atom by a consideration of the absorption or loss of velocity of the α -particles in passing through matter. The only data for this purpose so far obtainable are provided by the relations between velocity and thickness of matter traversed, in Al as determined by Rutherford, and in mica as determined by Geiger. A more complete investigation of these velocity curves in various substances is therefore of interest, more particularly as the earlier observations are subject to slight errors due to the assumption that equal thicknesses of matter have the same air equivalent at different parts of the range of α -particles. In the present experiments the velocity curves in Au, Cu, Al, mica, and air have been determined, using as source the α -particles of RaC. The velocities of the α -particles before and after passing through sheets of matter of various thicknesses are measured by the deflection of the particles in a known magnetic field. The mean value found for mv/e from the observed deflections is 4.00×10^5 e.m. units. In no case has it been possible to obtain with certainty a velocity of less than about 0.415 of the initial velocity of expulsion. It is possible that in the beam of α -particles after passing through 6.5 cm. air equivalent the velocities are distributed within the limits 89 to 47 % of the initial velocity. With further absorption the particles of higher velocities may become degraded in velocity. There is a difficulty in accounting for the absence of α -particles of lower velocities. It is possible they no longer produce scintillations. This point is investigated with different zinc sulphide screens, but with negative results. But even if they no longer produce scintillations then it is probable that they also no longer ionise, for the ranges of α -particles determined by the scintillation method are the same as those determined by the ionisation method. The results may possibly be explained by assuming that when the velocity of an α -particle falls below a certain value it is subject to a new special type of scattering, possibly by some kind of subcentral charge present in the atom. An alternate explanation may be obtained on the assumption that at this particular velocity the α -particle takes on an electron and then has only one positive charge. This would account for the limiting velocity coming practically the same in all the substances. An attempt is made to detect such singly-charged α -particles, but only one line of scintillations in the magnetically deflected beam is observed. Geiger apparently obtained one value of the velocity as low as 0.27; but attempts to repeat his conditions met with no success. Whether his result may prove correct or not there must be some very radical change accompanying the absorption of the α -particles when their velocity falls to 0.41 of the initial velocity. There is a discussion of the figures given for the velocity curves in the various materials.

A. E. G.

1838. Passage of β -rays through Matter. J. G. v. Jungenfeld. (Phys. Zeitschr. 14. pp. 507-514, June 15, 1918.)—Determines the ratio (μ/D_0) for various salts and alloys, where μ is the absorption coefficient for β -rays and D the density. The ratio represents the reciprocal of the penetrating power for an infinite thin layer. The results show that the penetrability of a compound decreases when one element is replaced by another of greater atomic weight. Thus, in the haloid salts, the fluoride, chloride, bromide, and iodide have increasing absorbing powers. The position of ammonium chloride between KCl and BaCl₂ is explained by the fact that it contains four H-atoms, which, according to Schmidt, possess great absorptive power. [See Abstracts, Nos. 1516 (1907) and 1498 (1910).]

E. E. F.

HEAT.

1839. *Thermal Conductivity of Air at Low Pressures.* A. Trowbridge. (Phys. Rev. 2. Ser. 2. pp. 58-64, July, 1918.)—Describes the determination of the conductivity of air at pressures of about a thousandth of a mm. of mercury undertaken as a subsidiary to another research still in progress. E. H. B.

1840. *Thermal Expansion of Liquids between Boiling-point and Critical Point.* J. Meyer. (Festschrift W. Nernst, pp. 278-301, 1912.)—By plotting the coefficient of expansion, between absolute zero and the critical point, against temperature, a curve is obtained having neither maximum nor minimum in the case of a normal liquid. When change in temperature is accompanied by change in molecular condition, curves are obtained showing maxima or minima or both, nitrogen peroxide, water, and nitrous oxide being examples of these three abnormal types. By means of a special apparatus, the expansion of liquids considerably above their boiling-points has been determined at very low pressures, e.g. water up to 200°, benzene up to 168°, ethyl alcohol up to 155°, methyl ethyl ether up to 85°, ethyl ether up to 115°, and isopentane up to 95° C., the results showing that the coefficient of expansion increases very considerably with the temperature, and in the case of the three last named, the expansion coefficient changing in a perfectly continuous manner when the transition from liquid to gas occurs at the critical temperature. With water, benzene, and ethyl alcohol, the observations were not carried to the critical temperature, but similar behaviour appears probable. W. H. St.

1841. *Capacity for Heat of Metals at Different Temperatures.* E. H. Griffiths and E. Griffiths. (Roy. Soc., Phil. Trans. 218. pp. 119-185, July 28, 1918. Roy. Soc., Proc. Ser. A. 88. pp. 549-560, July 18, 1918. Abstract.)—The authors have measured the specific heats of a number of metals at temperatures varying from 0° to 100°. Masses ranging from 1 to 4 kg. were used and were heated through a given temperature, not exceeding 1.4 deg., by electrical means, the temperature changes being measured by differential platinum thermometers. The apparatus was constructed with all the parts duplicated, two similar masses of metal being suspended by quartz tubes in similar air-tight brass cases, which were placed side by side in a large tank containing rapidly stirred water or oil. This tank was electrically controlled with great constancy at any given temperature (θ_0). One of the metal blocks remained at the tank temperature throughout the experiment, while the other, having been previously cooled below θ_0 , was heated to a similar extent above θ_0 by heat developed electrically in the centre of the block, the difference in temperature between the two blocks being determined at regular intervals. Any changes in the surrounding conditions would affect both blocks equally, measurement of the difference of temperature thus eliminating many sources of error. The dependency of the specific heat at temperature t lying between 0° and 97.5°, or, with zinc between 0° and 128.4°, is expressed by the following formulæ: Copper, $S_t = 0.09088 (1 + 0.0005841t - 0.00000048t^2)$; aluminium, $S_t = 0.20957 (1 + 0.0009161t - 0.0000017t^2)$; iron (ingot), $S_t = 0.1045 (1 + 0.001520t - 0.00000617t^2)$; zinc, $S_t = 0.09176 (1 + 0.0005605t - 0.00000178t^2)$; silver, $S_t = 0.05580 (1 + 0.0008896t - 0.000000141t^2)$; cadmium, $S_t = 0.05475$

($1+0.000520t-0.000000725t^2$); tin, $S=0.05868(1+0.0006704t-0.000000458t^2)$; lead, $S=0.08020(1+0.000400t-0.00000086t^2)$. If the values of S at 0° are plotted against the atomic weights (A), all the points show close approximation to the curve $S=4.804 \times A^{-0.75}$, except in the case of tin, for which the value of S exceeds the curve value by 4.6 per cent. Application of this relation to other elements for which the values of S are available shows good agreement in a number of cases and fair agreement (8-16 per cent.) in others, whilst in some instances the calculated and experimental values are totally different; among the last are carbon, the calculated value for which (0.458) is almost exactly four times that of the diamond (0.118), and amorphous boron, which gives an experimental value (0.250) very nearly half the calculated number (0.492). The experimental numbers for gases must be doubled to approach the calculated ones.

T. H. P.

1842. Specific Heat of Hydrated Salts. L. Rolla and L. Accame. (Accad. Lincei, Atti, 22. pp. 109-116, Aug. 7, 1918.)—The specific heats of sulphates of zinc, magnesium, and iron, containing different quantities of water of crystallisation, have been determined with a Schottky calorimeter, containing toluol [Abstract No. 2086 (1909)], and the molecular heats of the last molecules of water of crystallisation in the first two salts, and of the three last molecules of water in $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, calculated. These results agree fairly closely with the values deduced from Nernst's formulæ, so that the law of Garnier-Kopp is approximately verified. The molecular heats of the monohydrated sulphates of zinc and magnesia are 84.78 and 88.21 respectively. It is concluded that the molecular heat of water of crystallisation is, at ordinary temperatures, equal to that of ice.

W. H. Si.

1843. Improved Method for determining Specific Heats of Liquids, with Data concerning certain Dilute Acids and Alkaline Hydroxides. T. W. Richards and A. W. Rowe. (Amer. Acad., Proc. 49. pp. 178-199, Aug., 1918.)—An improvement on the apparatus previously used [see Abstract No. 1446 (1908)] is now described in which the alkali to be neutralised by acid in the centre of a calorimetric system in order to supply a definite quantity of heat, is now contained in a small Pt vessel which itself is inside the Pt vessel containing the acid. In this way equality of temperature before neutralisation is ensured. In the original apparatus the alkali was introduced from outside at the moment of neutralisation, which usually necessitated a correction being applied for its different temperature. Details of the preparation and purification of the substances used and of the determination of their specific heats are given. From the molecular heats obtained it is concluded that the thermal capacity of a solution of a strong acid or base containing at least 100 molecules of water per molecule is increased by the addition of water by an amount equal to the thermal capacity of the added water. It is thus possible to calculate the specific heat of any more dilute solution. The molecular heats of equimolecular solutions of the various substances used are also shown to vary in a systematic manner.

F. J. H.

1844. Experimental Proof of T^3 Law for Decrement of Specific Heats of Solids at Low Temperatures. A. Eucken and F. Schwes. (Deutsch. Phys. Gesell., Verh. 15. 14. pp. 578-588, July 30, 1918.)—Gives the results of various measurements of the specific heats of lead (from 15.95° to 92.0° abs.), of fluor-spar (from 17.5° to 86.0°), and of pyrites (from 21.7° to 84.0°). At low temperatures the molecular heats of fluor-spar and pyrites show a decrement

proportional to the cube of the absolute temperature, and this region extended from small (about 0.07 cal.) to relatively high values (about 1.0 cal.) of the molecular heat. Within this region the theory of Debye is valid. Over the whole temperature region the molecular heat of fluor spar follows the general function of Debye, whereas at higher temperatures pyrites shows distinct deviations from it. [See Abstract No. 446 (1918).] E. H. B.

1845. *Calculation of Specific Heats from Elasticities.* A. Eucken. (Deutsch. Phys. Gesell., Verh. 15. 14. pp. 571-577, July 30, 1918.)—Various recent researches agree in leading to the result that the energy density in solid bodies at low temperatures must satisfy the same relation as for radiation density, viz., the Stefan-Boltzmann law—

$$u = 1.0828 \frac{48\pi h}{c^3} \left(\frac{kT}{h}\right)^4 z;$$

in which h is Planck's universal *Wirkungsquantum*, T the absolute temperature, k the gas constant per molecule; c is for a solid body the mean speed of sound, for the ether the speed of light; finally z is a numerical factor which for a solid body has the value $8/2$ and for the ether is unity.

Following up this relation, the author concludes that it is at present to be accepted that the theoretically derived relation between elasticity and specific heat for crystals at low temperatures is valid and in agreement with experiment. [See Abstracts Nos 446 and 626 (1918).] E. H. B.

1846. *Determination of Specific Heats at Low Temperatures; Calculation of Electromotive Force.* II. F. Pollitzer. (Zeitschr. Elektrochem. 19. pp. 518-519, July 1, 1918.)—The author [see Abstract No. 866 (1911)] had dealt with galvanic cells from the standpoint of Nernst's heat theorem, and had relied on Einstein's formula for the atomic heat. This formula having since been modified by Nernst and Lindemann, he makes new experiments at temperatures from -100° down to the temperature of boiling hydrogen, and recalculates his former results. The new experiments concern Hg, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, Hg_2SO_4 , HgCl_2 , TiCl_3 , and ice; the values found agree with the modified formula. From those specific heats he deduces the electromotive forces of the combination $\text{Hg} | \text{HgCl}_2 | \text{PbCl}_2 | \text{Pb}$, and of others containing also Ag and AgCl ; they agree with the more recent experimental determinations of the heat of formation of HgCl_2 , AgCl , PbCl_2 , whilst differing very considerably from Thomsen's figures. The results also confirm the author's previous work which E. Cohen had attacked. H. B.

1847. *Sublimation of Metals at Low Pressures.* G. W. C. Kaye and D. Ewen. (Roy. Soc., Proc. Ser. A. 89. pp. 58-67, Aug. 1, 1918.)—Numerous observations, a *résumé* of which is given by the authors, have been made which show that metals volatilise at temperatures considerably below their melting-points. Experiments are now described which confirm the work of Reboul and Bollemont [Abstract No. 1768 (1912)] that there is, in addition to ordinary volatilisation, an emission of particles at right angles to the surface of heated metals similar to that obtained from the cathode of a discharge tube. Iridium heated in nitrogen at 20 mm. pressure, copper heated to 800° in nitrogen at 2 mm. pressure, iron heated to 960° , and tungsten to 1800° , both *in vacuo*, were used, and photographs are given of the results with copper and iron. The experiments with iron show the max. range of the particles to be about 1 cm. The deposit gives an iron reaction, but no loss

in weight of the specimen detectable by a chemical balance is observed. The surface of the specimen upon examination under a high-power microscope reveals a regularly oriented pitting, and the fact that this is more marked when the specimen is heated by direct current than when heated in a furnace leads the authors to suggest that the particle emission is electrical in origin. Suggestions based on the crystalline structure of the metal are also given. F. J. H.

1848. *Vapour Pressures of Metals*. I. H. v. Wartenberg. (Zeitschr. Elektrochem. 19. pp. 482-489, June 15, 1918.)—By the method used for the determination of the vapour pressure of silicon (Zeitschr. anorg. Chem. 79. p. 76, 1912) the author determines the vapour pressures of lead, silver, and thallium in hydrogen and nitrogen atmospheres within the pressure-range 10^{-5} to 10^{-6} atmo., and also the boiling-points and heats of evaporation of these metals. The results are tabulated. Copper and platinum showed, in a nitrogen atmosphere, at 1886° C. vapour pressures below 10^{-6} ; but tin evaporated noticeably. H. B.

1849. *Thermal Properties of Carbonic Acid at Low Temperatures*. C. F. Jenkin and D. R. Pye. (Roy. Soc., Phil. Trans. 218. pp. 67-117, July 28, 1918.)—Details of a continuous-flow method of measuring the various quantities necessary for constructing a $\theta\phi$ diagram for CO_2 between -50° C. and $+20^{\circ}$ C. are given, together with a comprehensive series of results and a diagram constructed from them. The direct measurements comprise: (a) Data for pressure-temperature curve of the saturated vapour; (b) Latent heat of vaporisation, total heat of the liquid and specific heat of the gas at various temperatures and pressures; (c) Joule-Thomson effect of the liquid; (d) Dilatation and elasticity of the liquid. From these are calculated: (e) Specific volume of the saturated vapour; (f) Specific heat of the liquid at constant pressure. The general procedure consisted in sending liquid CO_2 at temperature θ_1 and pressure p_1 , first, through a throttle valve to reduce its temperature and pressure to θ_2 and p_2 , then, at constant pressure p_2 through an electrically heated calorimeter to evaporate and superheat, and, finally, through a compression pump and condenser to bring it back to its original state. The temperatures of the CO_2 at various points were measured by means of inserted thermo-couples, the pressures by Bourdon gauges, and the current of CO_2 by steel weighing flasks placed in the liquid portion of the circuit. This general arrangement was suitably modified according to the quantity to be measured. The $\theta\phi$ diagram obtained, which includes liquid and gas limit curves, lines of constant total heat, and lines of constant dryness, is considered to be more accurate than that previously given by Mollier [see Abstract No. 961B (1904)], since it is constructed from the results of direct measurement, whereas that of Mollier is based on a mathematical equation obtained from experiments at higher temperatures. The agreement is, however, remarkable in view of the limited data Mollier had at his disposal and the very different method used in constructing the diagram. F. J. H.

1850. *Radiation Theory*. D. Hilbert. (Phys. Zeitschr. 14. pp. 592-595, July 1, 1918. Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 8. pp. 409-416, 1918.)—The author puts down five axioms regarding the monochromatic or total exchange of energy, the velocity of light, and the emission and absorption coefficients, and determines which combination of these axioms leads to Kirchhoff's laws. E. E. F.

SOUND.

1851. *Pianoforte Touch.* S. Pickering. (*Nature*, 91. pp. 555-556, July 81, 1918.)—The question as to whether what is known as touch is due to any peculiarity, apart from the energy, with which the hammer strikes the strings, and, consequently, with which the fingers strike the keys, would appear to be determinable by direct experiment. The author had always held that touch is dependent on such peculiarities, but has found as follows that the evidence is decidedly against this view. A note was struck one hundred times in succession so as to produce sound of as nearly as possible the same intensity; on half these occasions it was struck in a pressing or caressing manner; in the other cases it was struck sharply; the different kinds of blows were intermingled irregularly and according to a list previously drawn up, and the damper was held up while the note was being struck. As each note was struck a verdict as to its quality was given by a person sitting out of view of the piano, and this verdict was compared with the character of the blow given. This observer was not a trained musician, but was exceptionally appreciative of what is called "touch." Discarding all cases where the note had accidentally been more or less loud than the average, it was found that in 49 per cent. of the cases of uniform loudness the effect on the auditor coincided with the character of the blow given, in 51 per cent., the reverse. In another series of 100 notes, the values were 51 and 49 respectively. It is evident, therefore, according to this, that different quality of touch (in the above sense) produces no difference in the quality of the sound produced. Even if the independence of touch on the character of the stroke were fully established, there is no difficulty in explaining the apparent difference in touch of a performance with the fingers and one with a piano-player. At least seven factors may be specified as determining touch:—(1) Differences in loudness of a note or notes compared with that of preceding notes; (2) deviation from the theoretical value of degree of *staccato* or *legato*; (3) variations in time as compared with that of preceding notes; (4, 5, and 6) similar differences in loudness, duration and time of one note in reference to its nominally contemporary notes; (7) use of the loud pedal.

A discussion of the piano-player, its defects and possible improvements follows. E. H. B.

1852. *Dust-figures.* J. Robinson. (*Phys. Soc., Proc.* 25. pp. 256-268; Discussion, p. 268, June, 1918.)—The ripple formation in Kundt's tube was first satisfactorily explained by W. König in 1891. His theory was based on the hydrodynamical forces between two particles in a stream. All the known facts about these figures fall into line with the theory. The distance apart of the ripples increases with the intensity of the sound, and also from the node to the antinode there is a variation of the ripple pitch as required by theory. Certain measurements on dust figures produced by an electric spark have shown that these figures can only be explained in a similar way to the Kundt's tube figures. It was suggested by Cook [Abstract No. 1865 (1902)] that viscosity must be introduced in order to account for the formation of the ripples. The author here shows that it is possible to account for the ripple formation without the introduction of viscous forces at all. Indeed these act rather as a disturbance than a help. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1853. *Collisions of Slow Electrons and Gas Molecules*. II. J. Franck and G. Hertz. (Deutsch. Phys. Gesell., Verh. 15. 14. pp. 618-620, July 80, 1918.)—What was made highly probable in the first part of this work is now established, viz. that the collisions of electrons and gas molecules are the more elastic the less the affinity between the electrons and the molecules in question. For helium, hydrogen, and oxygen it is shown that the electrons needing energy for ionisation do not attain their proper free path. In helium the ionisation energy may be won by very many collisions, in hydrogen this number is curtailed, and in oxygen it is yet smaller, since the strong electronegativity of the oxygen causes distinctly unelastic collisions between electrons and its molecules. [See Abstract No. 1819 (1918).] E. H. B.

1854. *Plane Dispersion*. C. Schaefer and H[elene] Stallwitz. (Preuss. Akad. Wiss. Berlin, Ber. 86. pp. 674-686, 1918.)—Mathematical treatment of the plane diffraction of electromagnetic waves by gratings. [See Abstracts Nos. 1276 (1906) and 184 (1906).] E. H. B.

1855. *Observations of Atmospheric Electricity at Seeham, near Salzburg, in the Summer of 1912*. E. v. Schweidler. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 187-152, Jan., 1918.)—Conductivity of the air, potential gradient, and air-earth current were observed in the summer and autumn of 1912, and the following mean values were obtained for a position 500 m. distant from the shore of Lake Obertrümer:—Total conductivity = 2.78×10^{-4} e.s. unit; $q = \lambda_+/\lambda_- = 1.02$; potential gradient = 95 volts/m.; air-earth current = 8.2×10^{-7} e.s. unit per cm.². The diurnal range of potential gradient is small so that that of the air-earth current conforms with that of conductivity. At a second place of observation above the water near the shore the conductivity is markedly diminished, q is greater than unity, and the daily range of conductivity is considerably different from that at the former place of observation. [See Abstract No. 474 (1912).] R. C.

1856. *Observations of Atmospheric Electricity in Argentina*. G. Berndt. (Meteorolog. Zeitschr. 30. pp. 868-866, July, 1918. Paper read before the Deutsch. Wiss. Verein, Buenos Aires.)—Regular observations of atmospheric electricity on the continents of the Southern Hemisphere are very scanty. Beyond some observations of Neumayer in Melbourne, and of the French and English Antarctic Expeditions, there are few, if those at Samoa and Batavia, which are situated near the Equator, are omitted. The paper deals with observations made by Berndt, professor at the Physical Institute of Buenos Aires. The result of a year's observations of potential gradient and number of ions per cm.² near Buenos Aires, show that the former has a maximum in winter and a minimum in summer; while the number of ions is greatest in spring and summer, least in late autumn and winter. Both elements are thus dependent upon the seasons in the same way as they are in the Northern Hemisphere: a result in contradiction to that obtained from Ant-

arctic observations which made times of seasonal maxima and minima simultaneous all over the globe. The influences of meteorological changes are similar to those observed in Europe, except that rainfall was usually accompanied by a low positive potential gradient, rarely by a negative gradient. Diurnal variation of potential gradient is similar in character to the variation of northern latitudes. Observations were also made of conductivity, and velocity of positive and negative ions; and the air-earth current was deduced. The electricity brought down by rain was also measured and the results summarised.

R. C.

DISCHARGE AND OSCILLATIONS.

1857. Ionisation in Gaseous Mixtures by Röntgen Radiation. L. Simons. (Univ. of Durham Phil. Soc., Proc. 5. pp. 88-44, 1912-1918.)—Barkla and the author have given results of ionisation experiments with air, H_2 , O_2 , CO_2 , H_2S , SO_2 , and with the vapours C_2H_5Br , and CH_3I . [Abstract No. 900 (1912).] In the present paper experiments are described on mixtures of some of these. It is shown that the ionisation produced by silver X-radiation in a mixture of H_2S and O_2 in equal parts is 1.17 times that in a mixture of SO_2 and H_2 . Since the absorption by these two mixtures is the same ($\mu = 0.0089$) the results show that ionisation is not atomic. In further experiments the author studies the ionisation in mixtures of éthyl bromide vapour with H_2 , air, or SO_2 . The results show that the kathode radiation from the Br produces the same number of ions in C_2H_5Br , H_2 , air, or SO_2 for the complete absorption of its energy.

E. M.

1858. Recombination of Ions produced by Röntgen Rays. H. Thirkill. (Roy. Soc., Proc. Ser. A. 88. pp. 477-494, July 1, 1918.)—The work of Bragg and Plimpton has shown that certain peculiarities occur in the initial stages of recombination. It was the author's aim to measure the coefficient when the initial peculiarities have been dissipated, these being the only conditions under which the coefficient has a simple meaning. The method employed is a modification of that of Langevin, the gas between two electrodes being ionised by a single flash of X-rays, and the calculation of the coefficient of recombination based on measurements of the current passing through the gas for different electric fields. It is shown that in these circumstances the distribution of the ionisation is unimportant, and also that the effect of diffusion is negligible. The measurements were made with air, CO_2 , CO , SO_2 , and N_2O under very varied conditions as regards intensity of ionisation, pressure, etc., and the results show that recombination takes place according to the simple law $dn_1/dt = dn_2/dt = -an_1n_2$, where n_1 and n_2 are the numbers of positive and negative ions per c.cm. and a is the coefficient of recombination. For all the gases examined, and over a range of pressure of 200-760 mm. Hg the coefficient of recombination is shown to be proportional to the pressure.

E. M.

1859. Photoelectric Effect and Planck's Quantum. P. Debye and A. Sommerfeld. (Ann. d. Physik, 41. 5. pp. 878-980, Aug. 5, 1918.)—An elaborate and highly mathematical treatment of the theory of the photoelectric effect from the standpoint of the universal Planck's quantum h . It is at the outset assumed that this quantum is a general property of all purely molecular processes of the emissive or absorptive kinds. Thus for the photoelectric effect it is stated as follows:—An atom accumulates incident radiant energy in the motion of its electrons until the quantity of the action

$\int(T - U)dt$ reaches the value $h/2\pi$, where (as in the principle of least action in mechanics) T is the kinetic, U the potential energy of the electron under notice (here the energy of the quasi-elastic connection) h is the constant of the radiation law. When the action first reaches the value $h/2\pi$, the electron is set free from its atomic connection with the kinetic energy T .

The body of the paper is divided into two parts, treating respectively of monochromatic and natural light.

E. H. B.

1860. *Experiments on Columnar Ionisation.* E. M. Wellisch and J. W. Woodrow. (Amer. Journ. Sci. 86. pp. 214-230, Sept., 1918. Phil. Mag. 26. pp. 511-528, Sept., 1918.)—In a paper by Wellisch and Bronson [Abstract No. 1039 (1912)] a theory was put forward to explain the difficulty of obtaining saturation in the case of α -ray ionisation, the assumption being that an α -particle produces "neutrons" or unstable systems which are subsequently resolved into ions, probably by collision with ions already established. The present experiments were undertaken to test this point, the principle being that in the above theory it is to be expected that when the electric force is sufficiently great the electric current would be slightly greater when the field is longitudinal, or parallel to the α -particle column, than when it is transverse or perpendicular to it. The results confirm the accepted view of the phenomenon as advanced by Langevin and Moulin, namely, that "lack of saturation" of the ionisation current is due to columnar recombination, and no evidence was obtained which would indicate the existence of unstable atoms in the α -ray columns. The mean radius of the ionisation columns round the track of an α -particle is estimated as 0.0021 cm.

E. M.

1861. *Fluctuations in Ionisation due to γ -Rays.* P. W. Burbidge. (Roy. Soc., Proc. Ser. A. 89. pp. 45-57, Aug. 1, 1918.)—The experiments described are a continuation of those of Laby and Burbidge. [Abstracts Nos. 1850 (1911), 1221 (1912)], in which the existence of fluctuations in the ionisation due to γ -rays from radium was demonstrated. The author has obtained photographic records of the ionisation due to γ -rays, and estimated the value of the absolute fluctuation. The absolute fluctuation was calculated from Campbell's formula $\bar{\Delta}^2 = 2\bar{\sigma}^2 C / e^2 s^2 R$, where $\bar{\sigma}^2$ is the mean-square deviation of the image of the electrometer fibre, C the capacity of the system in cm., R is the resistance in e.s. units between the fibre, etc., and the earthed surroundings, s the sensitiveness per e.s. unit of voltage, and e the elementary charge. [See Abstract No. 678 (1910).] The fluctuation was found to be almost proportional to the ionisation when either the solid angle of rays used or the gas in the ionisation vessel was varied. The results are discussed on the various theories of γ -rays, and appear to lead to the deduction that a γ -ray is an entity in the sense that it has a discontinuous wavefront.

E. M.

1862. *Rays of Positive Electricity.* J. J. Thomson. (Roy. Soc., Proc. Ser. A. 89. pp. 1-20, Aug. 1, 1918.)—It is first shown that all the particles which have a given value of e/m strike the plane on a parabola, which latter can be photographed by allowing the particles to fall on a photographic plate. The apparatus and the conditions for obtaining photographs of these parabolas is next considered, together with the interpretation of the photographs. Using the method described, it is possible to distinguish between the following classes: Positively electrified atoms with one charge, positively electrified molecules with one charge, positively electrified atoms with

multiple charges, negatively electrified atoms, and negatively electrified molecules. There seems to be strong evidence that the charged atoms and molecules are produced by different agents. The photographs show that at certain places in the dark space there may be great changes in the production of charged molecules without any changes in the production of charged atoms. Another argument in favour of this view is the great variation that occurs in the relative intensities of the lines due to the atoms and molecules of the same element when the conditions of discharge are slightly altered. It is concluded that moving positively-charged atoms and molecules are in the main responsible for the dissociation which produces the positively-charged atoms occurring in the positive rays. The rarity of the double-charged molecule seems to indicate that the shock which produces the double charge is sufficiently intense to dissociate the molecule into atoms. The uniformity of the intensity of the parabolas corresponding to the multiply-charged atoms show that they acquire this charge at one operation and not by repeated ionisation on their way to the kathode. The occurrence of the multiple charge does not seem to be connected with the valency or the chemical property of the atom. The fact that these multiple charges so frequently occur on atoms of the inert gases tends to prove that they are not produced by any process of chemical combination. All the results point to the conclusion that the occurrence and magnitude of the multiple charge is connected with the mass of the atom rather than with its valency or chemical properties. No instance has been found where a molecule of a compound gas acquires a negative charge, and only two where a molecule of an elementary gas does so, viz., oxygen and carbon. The conditions which regulate the appearance of the negatively charged carbon molecule are very interesting. The negative molecule does not occur in compounds like marsh gas, CO_2 , CO , phosgene, and so on, where there is no linking between the carbon atoms. On the other hand, it does occur with compounds like acetylene, ethylene, ethane, where there are two carbon atoms linked together by one or more bonds. Since each parabola on the photograph indicates the presence in the discharge tube of particles having a known value of m/e , and as we can determine by the methods described what multiple e is of the unit charge, it is possible, by measuring the parabolas, to determine the masses of all the particles in the tube, and thus identify the contents of the tube so far as this can be done by a knowledge of the atomic and molecular weights of all its constituents. Thus it is shown that there can be little doubt that what has been called neon is not a simple gas but a mixture of two gases, one of which has an atomic weight about 20 and the other about 22. The parabola due to the heavier gas is always much fainter than that due to the lighter, so that probably the heavier gas forms only a small percentage of the mixture.

With reference to X_3 , though the largest quantities of that substance are obtained by bombardment with kathode rays, this is by no means the only source of the gas. It and helium are obtained when the discharge from a Wehnelt kathode passes through an exhausted tube. The most obvious suggestion, that it is a carbon atom with four charges of electricity, is shown to be not tenable. If X_3 does not contain a new element and is not carbon with four charges it must be triatomic hydrogen. From the physical side there is considerable evidence in favour of this view. The chemical properties of X_3 , however, in no way suggest hydrogen, so that if it is manufactured from that gas its relations to hydrogen must be very different from those of ozone to oxygen. The properties of X_3 brought to light by these experiments are : It can be kept over mercury for several weeks, though it is

diminished in amount at the end of that time ; it can be heated in a quartz tube for several hours without any appreciable change, although the quartz is at a red heat ; it can be sparked with oxygen and also with phosphorus without being destroyed ; it is not affected when passed over cold metallic sodium and when heated with sodium vapour it does not combine with it ; it can withstand the action of red-hot copper oxide and potash. These properties point to its being a very inert substance, and are not those we should expect an allotropic form of hydrogen to possess. There are, however, two cases where it enters into chemical combination : it combines with mercury-vapour when an electric discharge is sent through the mixture, and it combines, to some extent, with red-hot copper. Also X_2 is found to disappear when a mixture of it with hydrogen is sparked with sufficient oxygen to give a violent explosion. These properties point to the conclusion that if X_2 is an element it has considerable resemblance to the inert gases He and Ar, although its chemical properties are slightly more energetic. The absence of parabolas corresponding to $m/e = 1.5$ and $m/e = 6$ shows that if it is an element it is monatomic. Mendelejeff predicted the existence of an element of atomic weight 8 and attributed to it properties similar to those of fluorine, but of greater intensity. The chemical properties of X_2 are much too lethargic to be consistent with the view that it is a kind of super-fluorine. If X_2 is related to such an element, that element must have atomic weight 2 and not 8, and X_2 must be a stable compound of it with hydrogen. If this were the case, since the line corresponding to the element would coincide with that due to the hydrogen molecule, which is always on the plate, it would be difficult to get, by the study of the lines due to the positively charged particles, evidence as to its existence. Again, a substance possessing the energetic chemical properties of Mendelejeff's element should be able to attract a negative charge, and there should be on the negative side of the photographs a line for which $m/e = 2$. No such line has been detected. It has been proved in subsequent experiments that when the salts of Li, Na, K, or Rb are bombarded by cathode rays there is a genuine production, as distinct from liberation of absorbed gas, of He and X_2 , potassium giving the largest supply. This is of interest since potassium, as Campbell has shown, is radio-active. It is further shown that X_2 liberated from dissolved salts is not simply absorbed by them, but is either manufactured from hydrogen in the presence of water or liberated from the atoms of one or more of the elements in the salt, and that the presence of water is an important, it may be an essential, condition for the production by atomic disruption. If we suppose that X_2 is made from hydrogen, the function of the salt may be merely to supply the necessary water in a convenient form. X_2 is produced when the discharge from a Wehnelt cathode passes through gas at a low pressure, though in this case the bombardment of the walls of the tube by the cathode rays is feeble : this and its sporadic appearance in discharge tubes would be accounted for if it were produced from water-vapour.

A. E. G.

1863. *Number of Elementary Charges on Gaseous Ions*. P. Langevin. (Le Radium, 10. pp. 118-118, April, 1918.)—Townsend first showed that from a knowledge of the ratio of the mobility and diffusion coefficient of ions the ratio of the charges on the ions to the elementary charge could be calculated. His results showed that while negative ions were always singly charged, positive ions produced by penetrating X-rays were generally doubly charged [Abstract No. 662 (1908)]. The present paper deals with a direct method of measuring k/D (k = mobility, D = diffusion coefficient) for either positive or

negative ions. If two electrodes are very near together and the gas between is ionised by β - or γ -rays passing normal to the electrodes, then ions are produced practically uniformly and recombination may practically be neglected. From a consideration of these conditions the author shows that from the current potential curve k/D for both sets of ions can be evaluated. In particular if both positive and negative ions are singly charged, the curve is given by $i/I = (\epsilon^m + 1)/(\epsilon^m - 1) - 2/m$; here $m = kv/D$, I is the saturation current and i the current at potential V . Measurements by Salles appear to indicate that this equation holds and that both sets of ions are singly charged.

E. M.

1864. *Matter in its Electrically Explosive State*. F. E. Nipher. (Amer. Philosoph. Soc., Proc. 52. pp. 288-286, April, 1918.)—Singer in 1815 pointed out that a lead wire 0.01 in. in diam. could be exploded by passing an electrical discharge along it under suitable conditions. The present paper describes a variation of the experiment in which a condenser (of twenty sheets of glass 66 cm. square with tin-foils each 80 cm. square) was charged by an influence machine and then discharged through a $\frac{1}{4}$ -amp. fuse wire of diam. 0.115 mm. This wire was contained in a glass tube, 10 cm. long and 1 or 2 mm. bore, filled with coal-oil, all air being excluded. The leading-in wires practically filled the ends of the tube which were sealed with sealing-wax. A single discharge from either the positive or the negative side of the condenser, through the wire to earth, caused the tube of glass to be shattered into fragments so minute that their impact on the observer's face 6 ft. away produced no harmful effect.

E. H. B.

1865. *Silent Electric Discharges through Gases at Atmospheric Pressure*. E. H. Riesenfeld. (Festschrift W. Nernst, pp. 874-882, 1912.)—Continuing his work on the subject [Abstract No. 1609 (1911)] the author has determined the minimum potential required for passage of the silent discharge through the gases H, O, CO₂, and N, and its dependence on the dimensions of the "ozoniser," the nature of the glass, and the frequency of the alternating current. The minimum potentials for these gases, referred to H as standard, are not invariable, but the relative values increase with increasing size of the "ozonizer," and fall with increasing frequency of alternation. With quartz glass no silent discharge can be obtained, due probably to its insulating properties. The minimum potential for the silent discharge is distinctly lower than the sparking potential in continuous-current discharge, but the order of the gases, arranged according to minimum potential, is the same in both cases. The silent discharge through O and CO₂ is accompanied by hysteresis effects, so that their minimum potentials can only be obtained by gradually lowering the applied potential.

W. H. St.

1866. *Peculiar Form of Low-potential Discharge in the Highest Vacua*. R. J. Strutt. (Roy. Soc., Proc. Ser. A. 89. pp. 68-74, Aug. 1, 1918.)—The curious electrical effect described by Phillips [see Abstract No. 820 (1902)] is shown to be due to a residual positive static charge on the inner surface of the glass arising from the preliminary induction coil discharge between the iron electrodes at the centre of the bulb. This sets up a p.d. between the glass surface and the iron electrodes, which, upon the establishment of the magnetic field between the electrodes, causes a visible discharge lasting about 8 secs. The magnetic field simply reduces the p.d. required for the discharge. The author describes an experiment in which a continuous discharge of a

similar character is effected by an electrostatic machine, the kathode being a brass cylinder immersed in a magnetic field parallel to itself and the anode a concentric gauze cylinder. There is no discharge even with a p.d. exceeding 12,000 volts when the magnet is turned off, but 800 volts suffices to effect the discharge when the magnet is on. The electrons are considered to be sent by the electric and magnetic fields from the kathode to the anode in a spiral path whirling round the kathode. In this way they travel through a distance sufficient to ionise the gas without having to fall through a large p.d. An additional experiment bears out this explanation. F. J. H.

1867. *Simple Theory of Coupled Oscillatory Circuits, with Illustrative Oscillograms.* J. A. Fleming. (Phys. Soc., Proc. 25. pp. 217-226; Discussion, p. 226, June, 1918.)—The author gives a very short method, involving only the simplest algebra, for arriving at a formula for the time of free electrical oscillation of a leaky condenser in series with an inductive resistance, the oscillations being damped. The amplitude of the oscillations is proportional to the real part of e^{Pt} , where $P = p + ja$ and $p = 2\pi n$, n being the frequency and a the damping coefficient. Hence the volt drop down the resistance is $R + jPL$, and that down the condenser is $(S + jPC)^{-1}$. The sum of these two is zero, which leads at once to the equation—

$$P = p + ja = j \left(\frac{R}{2L} + \frac{S}{2C} \right) \pm \sqrt{\frac{1}{CL} - \left(\frac{R}{2L} - \frac{S}{2C} \right)^2},$$

giving the frequency and damping. The formulæ are confirmed by oscillograms taken at low frequency with a Duddell oscillograph. In the same manner the case of coupled circuits is considered and the e.m.f. equations are written in the form $Tim_1I_1 + jMP_1I_2 = 0$, $jMP_1I_1 + Tim_2I_2 = 0$, where Tim stands for $(R + jPL) + (S + jPC)^{-1}$. Eliminating the currents I_1 and I_2 , we have an equation which can be solved for p . Taking the reduced case of non-leaky condensers, tuned circuits, and zero resistance in the secondary, the equation deduced is—

$$[p^2CL(1 - k) - 1][p^2CL(1 + k) - 1] - a_1^2CL[1 - (1 + k^2)p^2CL] = 0,$$

which shows that there are, in general, oscillations of three frequencies in the circuits. This is confirmed by oscillograms. T. P. B.

1868. *Beaded Character of Kathode-ray Line.* C. T. Knipp. (Phys. Rev. 2. Ser. 2. pp. 89-48, July, 1918.)—The so-called magnetic spectrum of kathode rays has generally been considered to be due to the want of uniformity necessarily associated with the use of an induction coil. Recent experiments by the author suggest that the origin of the beaded character of the kathode-ray line may possibly be other than a want of uniformity accompanying the induction coil or static machine discharge. The apparatus used was the same as previously employed [Abstracts Nos. 555 and 1091 (1912)] with slight modifications. The Wehnelt kathode was removed and an ordinary Al kathode suitably mounted. The beam of kathode rays emergent from the canal passed between the nearly coterminous magnetic poles and electrostatic field plates and fell on the photographic plate beyond. This range was about 2 cm. After connecting the winch for turning the plate the containing vessel was sealed and evacuated. To get instantaneous photographs it was only necessary to rotate the plate while the discharge was passing. It appears from the photographs reproduced that in most cases the

beaded effect of the kathode-ray line may be accounted for by the oscillatory character of the electric discharge. However, a number of the photographs show beads whose spacing along the kathode line is not in agreement with that which should follow for damped oscillations. These may be due to ionisation or secondary effects, or possibly to group-velocity electrons given off by the kathode. The position of the kathode seems to have little or no effect upon the general character of the beads. The strongest evidence pointing to the oscillatory discharge as the origin of the beads is furnished by the photographs showing the negative crests. These crests in almost every instance correspond to the troughs in the beaded line. Assuming that the evidence submitted is sufficient to show that an oscillatory discharge under proper conditions results in a beaded kathode line, it seems that we have here a possible explanation of the beading of J. J. Thomson's molecular lines.

A. W.

1869. *Behaviour of Mercury Arc Rectifier under Alternating Current of High Frequency.* H. Busch. (Phys. Zeitschr. 14. pp. 524-528, June 15, 1918.)—The object of the investigation is to see whether the mercury arc behaves in the same manner for high-frequency as for low-frequency alternating current. This is found to be the case, and it is shown that a mercury rectifier with the ordinary connections can be driven by oscillations of over 2×10^6 per sec. A new and simplified method of connecting the rectifier is described, which may be used both for high and low frequency, and also for obtaining an alternating current of double the frequency of the original current.

T. P. B.

1870. *Generator of Short Electric Waves.* F. F. Martens and I. Ganswindt. (Deutsch. Phys. Gesell., Verh. 15. 18. pp. 557-559, July 15, 1918.)—Instead of a Hertz-linear sender the authors use two coaxial metal cones with the apices towards each other. The discharge takes place between the points of the cones through a stream of paraffin. Direct current at 440 volts or alternating current of frequency varying from 50 to 100,000 per sec. is used to excite the sender. The wave-length is 80 cm. The character of the oscillation is investigated by a Braun tube placed in the electric field of the oscillator. With alternating current at 50 \sim per sec., if the points of the cones are so far apart that no current passes, the usual sine curve is observed. But if the points are brought so near that discharge takes place, a zigzag is observed with rectangular bands at the points of the zigzag. These rectangular bands signify a radiation of constant amplitude and in each train there are about 7×10^6 waves.

T. P. B.

1871. *Atmospheric Refraction in Wireless Telegraphy.* W. H. Eccles. (Electrician, 71. pp. 969-970, Sept. 19, 1918. Paper read before the British Assoc. at Birmingham.)—A paper in which theory is developed to explain the bending of electric waves round the earth on the ground of the varying ionisation of the atmosphere. The fundamental theorem is that the velocity of electric waves through a gas is increased by the presence of ions of molecular size in the gas [see Abstract No. 1192 (1918)]. The velocity of long electromagnetic waves will thus exceed the velocity of light in an ionised medium. It is explained in a simple manner how this is the case. The trajectory of rays in an atmosphere, in which the index of refraction varies in a particular manner with the distance from the centre of the earth, is then examined. The theory gives a result which does not agree very well

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with the result which Austin and Cohen's empirical formula furnishes, but the absorption is supposed to be nil, and the assumed variation of the refractive index probably only roughly represents the truth.

T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1872. *Attainment of High Potentials by the Use of Radium.* H. G. J. Moseley. (Roy. Soc., Proc. Ser. A. 88. pp. 471-476, July 1, 1918.)—A radio-active substance which emits β -radiation should, when insulated, continue to gain a positive charge until it attains a potential V such that the energy of the emitted β -rays is equal to Ve . For radium emanation in equilibrium with its active deposit this potential is of the order 10^6 volts. The author has made experiments to test this point. A small bulb containing RaEm was supported by a quartz rod at the centre of a highly exhausted flask. A disc suspended from a quartz spring in the neck of the flask formed a simple attracted-disc electrometer. It was found that a bulb of 9 mm. diam. reached a potential of 160,000 volts in the course of a few minutes. A sudden discharge then occurred through the residual gas in the flask. A bulb of 5 cm. diam. charged up more slowly; no discharge took place and the final potential, 110,000 volts, was limited by a leak of electricity along the quartz support. The experiments thus provide a striking direct proof of the large amount of energy involved in the expulsion of a β -particle. The author also gives a discussion of the insulating powers of a vacuum.

E. M.

1873. *Method of Counting α - and β - Rays.* H. Geiger. (Deutsch. Phys. Gesell., Verh. 15. 18. pp. 584-589, July 15, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—Rutherford and Geiger in a previous paper [Abstract No. 246 (1913)] have described an apparatus for counting the α -particles emitted by radio-active substances. The present paper gives particulars of an arrangement of great simplicity and sensitiveness by which β -rays also may be counted. A brass tube about 2 cm. diam. and about 4 cm. long is closed at one end by an ebonite stopper through which a wire passes, lying along the axis of the tube and having a fine point. The point of the wire is distant about 0.8 cm. from the disc which closes the end of the tube. Through a small hole in the centre of this disc the rays to be counted can enter the ionisation chamber. The tube walls are charged to a positive potential of about 1200 volts, while the wire is connected up to a string electrometer. With this arrangement the kicks of the electrometer due to the entrance into the ionisation chamber of a single α - or β -particle correspond to potentials of from 10 to 20 volts. Examples are given of the use of the apparatus for counting the particles from a polonium preparation emitting about 4000 α -particles per sec. Reproductions are given of the photographic records.

A. W.

1874. *Experimental Proof of the Existence of Electric Dipoles in Liquid Dielectrics.* S. Ratnowsky. (Deutsch. Phys. Gesell., Verh. 15. 12. pp. 497-516, June 80, 1918.)—Debye [Abstract No. 571 (1912)] assumes that in the interior of insulators there are not only elastically-bound electrons but also dipoles of constant electric moment. From the results of his measurements of the dielectric constant of a 20 per cent. solution of amyl alcohol in benzene the magnitude of the moment of a dipole is calculated to be $m = 1.81 + 10^{-19}$, which is of the same order of magnitude as that calculated by Debye from the variation of the dielectric constant with the temperature.

T. H. P.

1875. Shape of the Ideal Electrocapillary Curve. F. Krüger and H. Krumreich. (*Zeitschr. Elektrochem.* 19. pp. 617-622, Aug. 15, 1918.)—According to the thermodynamical theory of Lippmann-Helmholtz, the electrostatic repulsion of the double-layer charge determines the change in the surface tension of the mercury, and $\partial\gamma/\partial E = -\epsilon$, where γ is the surface tension, E the p.d. reckoned from the maximum of the curve as zero, and ϵ is the areal density of the charge. To integrate, some assumption as to the capacity of the double layer has to be made. Regarding its electrode as a condenser of constant capacity, Lippmann put $\epsilon/E = C$, and thus found that $\gamma = \gamma_{\max} - CE^2/2$; that is to say, the curve should be a parabola. But the recent studies of polarisation capacities do not indicate that an electrode behaves as a condenser of constant capacity; the changes in the concentration at the electrode can, however, be calculated after Nernst, $E = RT \log (C/c)$. Even with this modification the curves are not found to be parabolas, the ascending (negative) branch always being steeper than the descending branch. Taking, however, the capillary electrometer of S. W. J. Smith (1900), and as electrolyte potassium nitrate with or without mercurous nitrate, and making the capillary very fine, 18 μ , the authors find that the curve does not differ from a parabola by more than 1 per cent. maximum. The capacity of the double layer is 27 mfd./cm². Other curves differ the more, the greater the tendency to complex formation in the mercurous salts, and the smaller the solubility of these salts, as Gouy had shown. H. B.

1876. Thermoelectric Properties of some Irreversible Nickel and Manganese Steels. S. Hilpert and F. Herrmann. (*Zeitschr. Elektrochem.* 19. pp. 215-219, March 1, 1918.)—Rods of steels 4 mm. in diam. were prepared containing 12.6 or 27.5 % Ni and 4.58, 11.7, 20.8 % of Mn, and were coupled with rods of constantan or of copper; they were then tested for thermo-electricity and magnetism at temperatures from +600° down to -186° C. The 27.5 % Ni steel behaved as regards thermoelectric hysteresis like a ferro-magnetic metal; the manganese sheets resembled magnetically the 12.6 % Ni steel, but showed no noteworthy changes in these thermoelectric forces at different temperatures. H. B.

1877. Vibration Galvanometers. H. F. Haworth. (*Phys. Soc., Proc.* 25. pp. 264-271; Discussion, pp. 271-272, June, 1918.)—(1) The maximum power available for vibrating the moving system of a vibration galvanometer of the moving-coil type is $V^2/4R$. As the frequency of the instrument is raised the losses increase rapidly, so it is an advantage to be able to increase the useful power input per unit voltage. To do this the resistance of the instrument must be decreased. This can be done in a galvanometer of the Duddell type by leading the current in and out at the bottom bridge and short-circuiting the wires at the top bridge. This results in a great increase of sensibility. A lower resistance also requires a lower flux-density. (2) Owing to the losses in the moving system increasing at a greater rate than the first power of the frequency, and to the fact that the frequency of the system increases at a slower rate than the reciprocal length of the string on account of the mass of the mirror, the flux density must be increased as the frequency increases, in order that the back e.m.f. of the moving system may always be half that of the applied p.d. (3) A combination of (1) and (2) makes a very satisfactory instrument with a much flatter voltmeter sensibility-frequency curve than usually obtained. [See Abstract No. 1487 (1912).]

E. H. B.

1878. *An Electric Converter*. **W. I. Book**. (Phys. Rev. 2. Ser. 2. pp. 49–57, July, 1918. Electrical World, 62, p. 898, Aug. 28, 1918. Abstract.)—The converter is designed to furnish high-frequency oscillations from a d.c. supply. The d.c. supply at 500 volts is made to send a spark through an air-gap between a circular disc and a concentric flat ring. The spark is caused to rotate round the gap by a magnetic field at right angles to the disc, and to secure the conditions for oscillations the ring is notched with about 10 notches per cm. A capacity and self-induction are connected across the spark-gap and, as the spark in passing round the gap alternately meets a maximum and minimum resistance in the notches, there is an alternating ebb and flow of energy in this circuit, setting up oscillations. The effects of varying the primary current, magnetic field, capacity, etc., are investigated, and the converter is stated to have been successfully used in wireless telegraphy.

T. P. B.

ALTERNATING CURRENTS AND MAGNETISM.

1879. *Magneto-optical Parameters of Iron and Nickel*. **C. Snow**. (Phys. Rev. 2. Ser. 2. pp. 29–38, July, 1918.)—Voigt's theory makes all types of Kerr and Faraday effects depend uniquely on the value of a certain complex parameter of the metal. An expression for the equatorial magnetic rotation is obtained, as a consequence of Voigt's theory, which is in good accord with the recent experiments of Ingersoll. The magneto-optical constants of iron and nickel have been computed from those experiments and from those of Foote. Formulæ for the magnetic rotation and ellipticity for the transmitted light have been obtained, and the amounts of the Kerr and Faraday rotation and ellipticity computed for yellow light. These are in close agreement with accepted values. The relative dispersion of these two rotations has been computed for a spectral range from 0.4μ to 2.1μ , and is in fair agreement with all the experimental results which have thus far been obtained for iron and nickel.

G. E. A.

1880. *Magnetic Materials in Claywares*. **A. Hopgood**. (Roy. Soc., Proc. Ser. A. 89. pp. 21–30, Aug. 1, 1918.)—An account is given of the observations on burnt clays, beginning with those of Boyle in 1691. In recent work [see Abstract No. 1506 (1900)] it is assumed that baked clays owe their magnetic properties entirely to the presence of magnetic oxide of iron, and that this is derived partly from the orientation of the magnetite originally present in the clays, and partly from the reduction of the ferric oxide of the clays during the process of burning. This view is considered too limited, and observations are detailed which show that white, cream, grey, yellow, buff, red, and brown claywares are feebly or moderately magnetic owing to the presence of black unfused grains of unchanged magnetic minerals and bluish-black fused globules of ferruginous silicates. Analysis of the magnetic globules indicates the presence of about 82 per cent. of ferrous iron in them. All baked claywares are magnetic, and great care must be exercised in the choice of these materials for use in magnetic observatories.

G. E. A.

1881. *Hall-effect in Liquid Electrolytes*. **A. E. Oxley**. (Roy. Soc., Proc. Ser. A. 88. pp. 588–604, July 18, 1918.)—The behaviour of solutions of copper sulphate, silver nitrate, and cadmium sulphate, and of copper sulphate gel has been studied in direct and reversed magnetic fields by means of a delicate Paschen galvanometer. In order to ensure the uniformity of the

magnetic field use was made of cells having areas very small (4 cm.²) in relation to that of the pole-pieces (50 cm.²); with the same object, the magnitude of the air-gap was reduced as far as possible. It is found that the Hall concentration effect contributes the greater proportions of the p.d.'s observed, the true Hall-effect being included. This preponderance of the concentration effect, depending on the sum of the ionic velocities of the electrolyte, prevents information being obtained regarding the nature of the process of reversal, such as was hoped for from an examination of electrolytes whose differences of ionic velocities vary considerably. In the eight experiments made, the p.d.'s are all of the calculated order, while they reverse with the magnetic field and act in the same direction under widely varying experimental conditions. These results are regarded as establishing the existence of a Hall-effect in liquid electrolytes.

T. H. P.

1882. *Force Exerted on a Magnetic Particle by a Varying Electric Field.* J. G. Leatham. (Roy. Soc., Proc. Ser. A. 89. pp 81-85, Aug. 1, 1918.)—Modern theory, which explains magnetism as a purely electrical phenomenon, defines magnetic force as a solenoidal vector whose curl is 4π times the electric current. It is considered an essential part of the test of the theory that the definitions should be justified by ascertaining the theoretical value of the force exerted on a magnetic particle by a varying external field. The expression found for the force contains the ordinary formula plus a second term which represents a mechanical force exerted on a magnet by a current of æthereal displacement.

G. E. A.

1883. *Method of Measuring Magnetic Permeability.* W. H. F. Murdoch. (Electrician, 71. pp. 976-977, Sept. 19, 1918. Paper read before the British Assoc., Birmingham, Sept., 1918.)—Description of a test carried out by means of the unipolar magnetometer method, and suggestion of an instrument based on this principle.

G. E. A.

1884. *Artificial Magnetic Storm.* F. E. Nipher. (Science, 87. p. 886, May 30, 1918.)—Reference is made to a previous paper in the same journal, in which evidence was presented to show that atmospheric ions tend to set like magnets along the lines of the earth's magnetic field. The effect of gusts of wind in disturbing these ions was also pointed out. An artificial local storm can be produced as follows: Place two bar magnets on opposite sides of a delicately suspended needle provided with mirror, telescope, and scale. Place a plate of glass over one magnet and sprinkle iron filings on it. The deflecting effect of that magnet is increased, and is balanced by moving the other magnet. Disturb the iron filings by means of a brush applied to any small area of the plate, and a magnetic storm is thus produced to which the needle responds. The daily variation in the earth's field may be explained as due to the change in permeability brought about by ionisation of the air by sunlight.

G. E. A.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1885. *New Current Interrupter for Spark Inductors.* (Electrotechn. Zeitschr. 84. p. 1065, Sept. 11, 1918.)—An interrupter known as "Eresco-Rythmeur" in which a number of carbon contacts are substituted for the usual Hg contact. It is claimed that with a current of 40 amps. and voltage of 440 for one hour the contacts do not deteriorate.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1886. *Density and Atomic Weight of Helium.* W. Heuse. (Deutsch. Phys. Gesell., Verh. 15. 18. pp. 518-528, July 15, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—Helium was obtained from thorianite and purified by the usual method, after which the density was determined by weighing, using a glass counterpoise of about the same weight and volume as the vessel containing the gas. The weight of a normal litre of helium, as a mean of seven experiments, is found to 0.1785 ± 0.0000 gm., from which the atomic weight is calculated to be 4.002. [See Abstract No. 2224 (1906).]

T. S. P.

1887. *An Oxidisable Variety of Nitrogen.* T. M. Lowry. (Faraday Soc., Trans. 9. pp. 189-192, July, 1918.)—A supplement to the paper noticed in Abstract No. 1591 (1912). Andreoli ozonisers are combined with groups of spark-gaps so that the air is exposed to the silent discharge and also to a spark discharge between pairs of iron studs; the sequence of the two discharges can be reversed, and the gases be examined after having undergone one treatment or the combined treatment. The spectra obtained with the aid of a wooden trunk, 8 in. square, 64 ft. (or 15 ft.) in length, are now reproduced. The conclusion is drawn that the ozone oxidises a modified nitrogen to peroxide, though Strutt could not oxidise his active nitrogen by ozone under the conditions of his (Strutt's) experiments. In the technical fixation of nitrogen the chief feature would appear to be to produce the disrupted active nitrogen and to bring it in contact with atomic or ozonised oxygen before it reverts to the inactive form.

H. B.

1888. *Adsorption by Heated Charcoal.* K. Arndt and G. Schraube. (Festschrift W. Nernst, pp. 46-52, 1912.)—Carbon dioxide and CO are shown to be both adsorbed by carefully purified wood charcoal, CO₂ being the more readily adsorbed, and the volume ratio of the adsorbed gas being, at the ordinary temperature, 8.4 : 1. If the gas adsorbed by charcoal from a mixture of CO₂ and CO is removed in successive fractions, the ratio of CO₂ to CO increases very considerably in the later fractions, a similar variation in the ratio being also found in the successive fractions obtained from charcoal placed in CO₂ for several hours at 750-800°, indicating that the adsorbed gas is under considerable pressure, which tends to displace the equilibrium between C, CO, and CO₂ in favour of the CO₂. Similar results are obtained by placing the charcoal in a mixture of CO₂ and N at 200°, 800°, and 400°.

W. H. St.

1889. *Absorption of Active Hydrogen by Platinum.* A. E. Freeman. (Amer. Chem. Soc., Journ. 85. pp. 927-981, Aug., 1918.)—The use of a Hale-Pirani vacuum manometer has led to the observation of various phenomena difficult of explanation. This manometer consists of Pt-wire, 1.1 mil in diam., mounted on glass supports and sealed in a thin-walled glass bulb, a constant current of about 0.00925 amp., taken from a special storage battery being sent through the wire which is thus heated to about 125°. At low pressures the equilibrium temperature of the wire, and therefore its

resistance, is a function of the gas pressure. The manometer is calibrated by taking the resistance of the wire at various pressures—as low as 0.00002 mm. of mercury—which are measured by a sensitive, accurate McLeod manometer. The calibration curve thus gives resistance of the wire in terms of the pressure and is a straight line below 0.0005 mm. The zero-pressure resistance is found by extrapolation.

In measuring the pressures in incandescent lamps it was found that, after a lamp had been burning for about 50 hours, the zero-pressure resistance was often exceeded, a negative pressure being thus indicated. In view of the theory propounded by Langmuir concerning the presence in incandescent lamps of the active modification of hydrogen formed by the decomposition of traces of water-vapour by the filament [see Abstracts Nos. 523, 891 (1918)], it seemed possible that the atomic hydrogen would recombine at the Pt filament and thus furnish heat to produce the abnormal action in the manometer. Interposition between the lamp and manometer of either a glass U-tube immersed in liquid air or a plug of glass wool prevented the appearance of the negative pressure, presumably owing to the adsorption of the active hydrogen. That the abnormally high resistance of the Pt is not, however, due to the heat developed by the recombination of hydrogen atoms is shown by the persistence of these negative pressures for 50 hours after the current is cut off from the lamp, and it seems probable that the absorption of the active hydrogen by the Pt causes the increased resistance of the latter. When air is let into the apparatus the specific resistance of the Pt falls to its original value, owing evidently to oxidation of the atomic hydrogen.

T. H. P.

1890. *Chemical Reactions at very Low Pressures. II. Chemical Clean-up of Nitrogen in a Tungsten Lamp.* I. Langmuir. (Amer. Chem. Soc., Journ. 85, pp. 981-945, Aug., 1918).—Further investigation [see Abstracts Nos. 523, 891 (1918)] shows that nitrogen in a lighted tungsten lamp disappears in three ways: Chemically, electrochemically, and electrically, the chemical clean-up depending on the combination of the nitrogen with tungsten-vapour to form the brown compound WN_3 . From zero pressure up to about 0.001 mm., the rate of chemical clean-up is proportional to the product of the rate of evaporation and the pressure of nitrogen, whilst from 0.008 to about 1 mm. the rate is proportional to that of evaporation and independent of the pressure; at pressures exceeding 2 mm. the rate is still proportional to that of evaporation, but the latter is reduced materially by the presence of the gas. At no temperature does nitrogen react perceptibly with solid tungsten. The rate of evaporation of tungsten *in vacuo* at any temperature T (Kelvin) is given by the equation, $\log_{10} M = 15.402 - 47444/T - 1.4 \log_{10} T$, where M is expressed in gm. of tungsten per sec. per $cm.^2$ of surface. The vapour pressure of tungsten in mm. of mercury is given by the expression, $\log_{10} p = 15.502 - 47444/T - 0.9 \log_{10} T$, and at the melting-point ($3540^\circ K.$) is 0.080 mm. The boiling-point of tungsten is in the neighbourhood of $5000^\circ K.$ and the heat of evaporation is very high, namely, $\lambda = (219000 - 1.8 T)$ gm.-cals. per gm.-atom. As regards the mechanism of the reaction, the tungsten-vapour given off by the filament is monatomic, and when each atom of the vapour collides with a nitrogen molecule, it reacts with it to form WN_3 , it being unnecessary for the nitrogen to be dissociated or ionised. Tungsten atoms striking the bulb do not react with a layer of absorbed nitrogen, possibly owing to the absence of such layer under the experimental conditions. The compound WN_3 has a clear, brown colour in thin layers and is decom-

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posed by water to form ammonia and probably WO_3 ; it is stable in a vacuum at 400°C . but is decomposed at 2400°K . The electrochemical clean-up of nitrogen takes place at much lower temperatures (1900°K .) than the chemical, when potentials much over 40 volts are used in a way which causes a perceptible discharge through the gas; no fatigue effect occurs and the nitrogen in this case combines with tungsten to WN_2 . The electrical clean-up proceeds at pressures of 0.005 mm. or less, with a voltage of 250 and high filament temperatures. It is very erratic and exhibits marked fatigue effects, sometimes with alternate evolution and clean-up of nitrogen as the temperature or voltage is varied. Part, at least, of the nitrogen is easily recovered by heating the bulb.

The behaviour of Pt towards oxygen is in every way analogous to that of tungsten towards nitrogen; at low pressures the oxygen combines with Pt-vapour to form PtO_2 , but does not attack solid Pt. T. H. P.

1891. *Theory of Electrical and Chemical Atomic Forces*. A. Byk. (Deutsch. Phys. Gesell., Verh. 15. 18. pp. 524-538, July 15, 1918.)—The author puts forward a theory of the atom based on the assumption that in the interior of the atom non-euclidean geometry holds, and then discusses the application of the theory to the physics and chemistry of the atom. In the case of the alkali metals, Li, Na, K, and Rb, the ratios between the atomic radii and the distances apart of the atoms, as calculated by the formula deduced by the author, are found to be constant within 3 %, which lies within the limits of error. The heats of dissociation and the cross-sections of various molecules of the elements are calculated and compared with the experimental results.

T. S. P.

1892. *Studies on Sulphur, Selenium, and Tellurium*. E. Beckmann. (Preuss. Akad. Wiss. Berlin, Ber. 40. pp. 886-894, 1918.)—The cryoscopic constant of sulphur, as determined by measurements on solutions of naphthalene, diphenyl, aniline, etc., in sulphur, is found to be 218, from which the latent heat of fusion is calculated to be 14.1 cal. From these results, and the measurements of Smith and Holmes on the content of amorphous sulphur in sulphur which has been heated at different temperatures, the molecule of amorphous sulphur is calculated to be probably S_8 . The author then puts forward a theory as to the molecular state of sulphur at different temperatures. Sulphur dissolves in iodine, without chemical combination, as the molecule S_8 , whereas Se, in the same solvent, has the molecule Se_2 . This dissociation of selenium is not a temperature effect, since in other solvents, at higher temperatures, the molecule is Se_2 . Tellurium does not dissolve in iodine without chemical combination occurring.

T. S. P.

1893. *Calcium Boride*. E. Wedekind. (Ber. Deut. Chem. Gesell. 46. 8. pp. 1885-1889, 1913. Chem. News, 108. p. 96, Aug. 22, 1918. Abstract.)—When calcium metaborate (80 gm.) is reduced with 50 gm. of calcium in the author's electric vacuum furnace (described in Ber. 46. pp. 1198-1207, 1913), CaB_2 is gained; extracted with acetic and hydrochloric acids and water the boride forms a fine brownish microcrystalline powder of density 2.11 at 18° ; it superficially oxidises to borate when heated in air. When the arc plays between electrodes made of the compressed powder the boride, which conducts the current, sinters to a hard mass which cuts glass. The boride resists acids and alkalis, but is decomposed by fused caustic alkalis.

H. B.

1894. Nickel Brasses. L. Guillet. (Rev. de Métallurgie, 10. pp. 1180-1141, Sept., 1918.)—In Abstract No. 1819 (1906) the author's results were mentioned which led to equivalents for several metals in substitution for copper in the copper-zinc brasses containing from 55 to 68 % Cu; Abstract No. 1804 (1906) further deals with the data upon which the theory was based. In the present paper the importance of finding a metal which when added to the brasses has a negative equivalent is pointed out. Nickel appears to behave in this way, its coefficient l being -1.8 . Four series of tensile, shock, and indentation tests, and photomicrographs, are given for alloys containing 50 and 55 % Cu, and 0 to 10 % Ni, as cast respectively in chills and in sand. The mechanical properties in all cases are the same as those of the Cu-Zn binary alloy which has the same structure, so long as the structure is not that of a Cu-Zn alloy beyond the limits 55 to 68 % Cu. This means that the addition of Ni is as advantageous as the addition of rather more Cu. Test results in two instances are also given for drawn, and drawn and annealed, nickel brasses, showing close agreement with the theory of equivalents. It is further pointed out that there is no need to reject nickel-plated pieces from among scrap from the brass foundry, so long as one is certain that the nickel hides nothing but brass. It appears that the fact that Ni forms an unbroken series of solid solutions with copper explains why Ni substitutes copper in the manner described. The author is investigating the general validity of this theory.

F. R.

1895. Hardness of Aluminium-Silver Alloys. G. Le Grix and W. Broniewski. (Rev. de Métallurgie, 10. pp. 1055-1064, Aug., 1918.)—A brief review and bibliography of the work done on the hardness of alloys is given in the paper. The hardness of Al-Ag alloys has been studied by the Brinell method using a glass ball 1 mm. diam. under a pressure of 5 kg., and the results have been compared with the conductivity and temperature coefficient of electrical resistance of the same series of alloys. In addition to the hardness-volume concentration diagrams the authors have plotted softness-concentration curves, in which "softness" is defined as the faculty for undergoing permanent deformation and is represented numerically by the reciprocal of the hardness. These curves are similar to the conductivity and temperature-coefficient curves. The compound Al_3Ag_2 is sharply defined at a maximum on the curves, while the compound $AlAg_3$ corresponds to a discontinuity on the softness curve which also shows a discontinuity between these two points, corresponding with the micrographic change. As a result of their work the authors conclude that the study of hardness is not so precise as the thermal or electrical methods of determining constitution, but is very useful as an auxiliary method.

F. C. A. H. L.

1896. Action of Sulphur Dioxide on Copper at High Temperatures. C. M. Stubbs. (Chem. Soc., Journ. 108. pp. 1445-1461, Aug., 1918.)—The depression of the freezing-point of copper by SO_2 was found to be about 2.54 times that expected if SO_2 were simply dissolved as such. This is explained upon the assumption of a partial reaction of the gas with the copper. The concentration varies as the square root of the pressure [see Abstract No. 800 (1911)]. If the reaction is about 70 per cent. complete at atmospheric pressure, the concentration varies as the square root of the pressure in the ratio found by Sieverts and Krumbhaar (*loc. cit.*). Such a partial reaction would give a depression about 2.4 times that calculated for the formula SO_2 , which is in approximate agreement with the author's experimental value. These views

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are supported by the results of experiments on the influence of excess of Cu_2S or Cu_2O on the depression caused by SO_2 . Results are given for the equilibrium pressures of SO_2 in the univariant system Cu , Cu_2O , Cu_2S (all solid), and SO_2 , between 700° and 1050° , the pressure rising from a fraction of 1 atmo. to 7 atmos. Incidentally 1055° is deduced as the temperature of solidification of the triple eutectic of the three solids. The high value of the equilibrium pressure at this temperature, namely, 7 atmos., is in agreement with the very low solubility at ordinary pressures at the same temperature, noted in the Abstract already referred to. At the high temperatures and pressures it appears that the equilibrium may depend upon an influence of Cu_2S and Cu_2O upon each other's solubility. F. R.

1897. *Effect of Casting Temperature, etc., upon a Copper-Tin Alloy.* E. Heyn and O. Bauer. (Königl. Materialprüfungsamt, Mitt. 81. 8. pp. 158-164, 1918.)—The alloys of the class Cu 95, Sn 4, and Zn 1 per cent. are occasionally brittle both as cast or as rolled. A tough and a brittle strip are sometimes obtained from the same crucible of metal. The results of some tests upon cast and rolled strips of the tough and brittle kinds are given. Repeated bending and one-blow shock tests show this difference. The fracture of the brittle metal showed blow-holes. The microscope showed the structure of the brittle specimens to consist mainly of a solid solution, which indicates slow cooling, due to too high a casting temperature or too hot a mould. The presence of the blow-holes confirms the probability of too high casting temperature. The resistance to shock was increased by cold working followed by annealing for half an hour at 600° . F. R.

1898. *Displacement of the Critical Points of Iron by Addition of Silicon.* G. Charpy and A. Cornu. (Comptes Rendus, 157. pp. 819-822, Aug. 4, 1918.)—Cooling-curves of seven mild steels (0.11 to 0.22 % C) containing 0.11 to 6.10 % Si, have been taken by means of the Saladin-le Chatelier galvanometer. The results show that Si raises the temperature of A_2 but diminishes its intensity until it disappears at about 2 % Si. Increasing Si-content lowers A_2 (10 to 12 deg. C. per 1 % Si) but raises A_1 until the two points combine at 8.16 % Si. At 8.94 % Si two points again appear, but at higher percentages (about 50 % Si) the upper point disappears. Microscopic and chemical examination indicate that above 8.2 % Si the positions of the points A_1 and A_2 are reversed, e.g. in the 8.94 % steel A_1 appears at 720°C . and A_2 at 690°C . In the higher alloys the point A_1 disappears owing to retention of the carbon in the graphitic state. The point A_2 , however, is lowered continually with increasing Si. These results have been confirmed in a steel containing 0.85 % carbon. F. C. A. H. L.

1899. *Proposed Modification of the Iron-Carbon Diagram.* A. Vinogradoff. (Rev. de la Soc. Russe de Métallurgie, pp. 284-288, 1912. Rev. de Métallurgie, 10. pp. 498-494, Sept., 1918. Abstract.)—In the ordinary equilibrium diagram of the iron-carbon system the horizontal line MO at about 780° , marking the change from β to α , is argued not to represent all the facts satisfactorily. It is proposed to add another set of curves for temperatures below 600° , similar to those now adopted for the higher temperatures. In accordance with these suggestions, β iron dissolves iron carbide forming osmondite. Martensite (and troostite) are due to the uniting of the γ and β phases—represented by austenite and osmondite respectively. Sorbite is probably a eutectic of osmondite and cementite. F. R.

1900. *Hardening Hypereutectoid Tool Steel*. S. S. Steinberg. (Rev. de la Soc. Russe de Métallurgie, pp. 618-615, 1912. Rev. de Métallurgie, 10. p. 502, Sept., 1918. Abstract.)—Some tool steel which broke with a coarse fracture was found to have a cementite network, and reheating at various temperatures, followed by quenching did not cure the trouble. The steel was then quenched from above A_c in boiling water, and again hardened, with good results. It is pointed out that, as would be expected, the first quenching serves to retain the cementite solution, which could not be attained by heating to the ordinary quenching temperature. F. R.

1901. *Cast Iron and Malleable Cast Iron*. W. H. Hatfield. (Rev. de Métallurgie, 10. pp. 987-948, Aug., 1918.)—The alloys of iron and carbon are discussed from the point of view of the phase-rule and the modern equilibrium diagram. Foundry cast irons and malleable cast irons are illustrated by photomicrographs and the principles underlying the conversion of white iron into malleable cast iron are described, due attention being paid to the actions of Si, S, P, Mn, etc., on the stability of the carbide. F. C. A. H. L.

1902. *Volume-changes in Quenching Steel*. M. Oknoff. (Rev. de la Soc. Russe de Métallurgie, pp. 616-681, 1912. Rev. de Métallurgie, 10. pp. 502-508, Sept., 1918. Abstract.)—Carbon steel quenched from above A_1 has a greater volume than the same steel before quenching. The increase of volume depends mainly upon the carbon-content, and increases with it and the speed of cooling. It is, however, practically independent of the quenching temperature between 700° and 1000° . Steels containing from 0.2 to 0.5 per cent. carbon, quenched at from 750° to 800° , have a slightly smaller volume than the same steels quenched from 700° . It is suggested that this is due to the presence of β -iron in the steels quenched at from 750° to 800° . In high-carbon iron-carbon alloys repeated quenching decomposes free cementite, resulting in erratic increases of volume which mask the increases that accompany hardening. F. R.

1903. *Over-oxidation of Steel*. W. R. Shimer and F. O. Kichline. (Amer. Inst. Mining Engin., Bull. No. 81. pp. 2861-2877, Sept., 1918.)—Oxygen estimations and photomicrographs are given for samples taken at various stages in blowing metal in the Bessemer converter for use in the Duplex process. The details of each heat studied should be noted in the original, but the principal conclusions at which the authors arrive are the following:—Efforts were made to obtain the greatest possible over-oxidation, by over-blowing and by the addition of ore. The highest oxygen contents attained by over-blowing were 0.074, 0.064, and 0.049 %, despite the fact that samples were taken at once and cooled promptly. By adding ore, after the blow, the greatest oxygen-contents obtained were 0.029, 0.028, and 0.088 %, the samples being taken as soon as the ore was melted into the slag. When time was allowed for the oxygen to escape after the ore addition 0.017 % of oxygen was found. The excess of oxygen disappeared in a very few minutes of standing, or was removed upon addition of molten mixer metal. The presence of a mixer skull in the bath, or over-oreing, resulted in excessive amounts of manganese silicate being present in the steel. A basic open-hearth cast made under extremely oxidising conditions gave only 0.024 % oxygen. The carbon was 0.05 %, and the sample was taken before adding the ferro-manganese. Results on steels as forged or cast were practically identical. The oxygen-contents of open-hearth rail steels ranged from 0.019

to 0.016 % ; those of sections from 0.024 to 0.014, the carbon-content being about 0.019 %. It appears improbable that above 0.080 % oxygen can be obtained in ordinary Bessemer and basic open-hearth practice, after adding decarburisers, or over 0.075 under any circumstances. Results higher than these figures must therefore be due to oxidation during teeming or to imperfect drillings. The oxygen determinations were made by a slight modification of Ledebur's method, and some particulars of the investigation and of the details adopted are given. F. R.

1904. *Coefficient of Flow and its Importance during Casting in Metal Ingot Moulds.* A. Portevin. (Rev. de Métallurgie, 10. pp. 948-951, Aug., 1918.)—Among the various factors acting on the quality of metals and alloys cast into ingots, and one which is quite neglected in works on foundry practice, is the rate of casting or rate of flow of the metal in the mould. After pouring, the metal remains liquid in the mould for some time, solidification being ultimately propagated from the bottom to the top of the ingot ; the length of time during which the metal remains fluid is determined by the rate of solidification, and has an important bearing on the quality of the metal produced. The velocity of solidification depends upon a large number of factors—on the temperature of fusion, specific heat, and latent heat of fusion of the alloy, on the dimensions, temperature, heat conductivity and specific heat of the ingot mould, on the conditions and temperature of casting, on the velocity of rise of the surface of the metal in the mould, and so on. The last-mentioned factor increases with the sectional area of the feeder and decreases with the sectional area of the ingot ; to the ratio of these two areas the term "coefficient of flow" has been applied, and its best value determined for a number of copper alloys. It has been found to vary according to the nature of the alloy, the size of the ingot mould, and the material of which it is made. F. C. A. H. L.

1905. *Measurement of Electrical Quantities in Siemens Ozone Tubes.* V. Ehrlich and F. Russ. (Zeitschr. Elektrochem. 19. pp. 830-840, April 15, 1918.)—The measurements were made with the aid of a Dolezalek binant electrometer and a Gehrcke glow-light oscillograph ; particulars of the arrangements are to follow. It results that the ionisation current and potential are always in phase ; thus the potential across the gas-gap between the glass tubes is a measure of the energy consumption, and all means which reduce the minimum effective potential will increase the energy yield. The discharge was sent through dried air. H. B.

1906. *Neutral Oil Emulsion as a Model of a Suspension Colloid.* R. Ellis. (Faraday Soc., Trans. 9. pp. 14-25 ; Discussion, pp. 26-28, July, 1918.)—The interface potential at the surface of the oil globules of an emulsion was measured by means of a microscope slide apparatus. It was found to be little affected by organic impurities in the oil, but to be altered enormously by acids, and to a lesser degree by alkalies. The max. interface potential was found to correspond with a concentration of about 0.001-N alkali, and this was found to be the point of max. stability of the emulsion. Surface-tension measurements showed that the stability did not depend on the surface tension but on the interface potential. Determinations were made of the concentrations of salts with mono-, di-, and tri-valent kathions required to neutralise exactly the charge on the oil globules. The ratio of these concentrations was found to form a geometrical series agreeing with that obtained by coagulation experiments. The coagulation of oil emulsions by colloidal ferric hydroxide

was next tried, and it was found that the oil was completely precipitated within two well-defined limits on either side of the iso-electric point of the oil emulsion. The coagulation appears to be due to surface precipitation effects, somewhat analogous to the condensation of water-vapour on surfaces of various curvatures, taking place between the oil globules. T. S. P.

1907. *Formation of Aluminium Nitride from Alumina, Coal, and Nitrogen.* I. W. Fraenkel. (Zeitschr. Elektrochem. 19. pp. 862-878, April 15, 1918.)—The furnace is of the F. Fischer type, being a glass globe with projections; the carbon tube to be heated forms a diameter together with the graphite cylinders into which it fits. The charge consists of an intimate mixture of soot and alumina in the ratio $1C : 2Al_2O_3$; it is compressed into pellets which are crushed. Temperatures were measured with a Holborn-Kurlbaum pyrometer. The formation of AlN begins with very finely powdered materials below $1400^\circ C.$, and is brisk at $1500^\circ C.$; reduction of the nitrogen pressure from 1 to 0.88 atmos. had hardly any effect; the presence of CO is detrimental; the endothermic reaction is $Al_2O_3 + 8C + N_2 \rightleftharpoons 2AlN + 8CO$. Alumina is easily reduced to the carbide Al_4C_3 by C and CO; this carbide sublimes and may disturb the observation; the carbide is possibly the intermediate product in the nitride formation. Different kinds of carbon (charcoal, coke, graphite) react with different velocities; this is being further investigated. H. B.

1908. *Dissociation Isotherms of Sulphur, Selenium, Arsenic, and Phosphorus.* G. Preuner and I. Brockmüller. (Zeitschr. Phys. Chem. 81. pp. 129-170, 1912.)—Employing a modification of the quartz-glass manometer described by Preuner and Schupp, the results obtained by these investigators for sulphur [Abstract No. 1045 (1910)] have been confirmed, and from the equilibrium $4CuS \rightleftharpoons 2Cu_2S + S$, it is concluded that the conversion of 64 gm. solid rhombic S into gaseous S_2 molecules involves an absorption of 82,500 cal. Experiments with selenium, for which dissociation isotherms and vapour-pressure curves are given, show this to exist chiefly as Se_2 and Se_8 , up to $900^\circ C.$, at which temperature there are a small number of Se_1 molecules, while below 500° there are probably some Se_8 . Gaseous Se_8 absorbs 55,960 cal. in passing into $8Se_2$. Dissociation isotherms of As and P are also given, the former being shown to exist as As_4 , As_2 , and As_1 molecules in the gaseous state between $600^\circ C.$ and $1200^\circ C.$, and the latter as P_4 , P_2 , and P_1 between the same temperatures. In the conversion of gaseous P_4 to $2P_2$, 81,500 cal. are absorbed, and P_2 molecules to $2P_1$ 45,500 cal. W. H. S.

1909. *Electrolytic Theory of the Corrosion of Iron.* B. Lambert. (Faraday Soc., Trans. 9. pp. 106-114, July, 1918.)—American writers have discussed the electrolytic theory of the corrosion of iron from the point of view of Nernst's conception, and it seems to follow from their reasoning that even chemically pure and physically homogeneous iron ought to rust in contact with air and deposit copper from its solutions. The author's experiments [Abstract No. 782 (1918)] have proved beyond all doubt that pure iron can be prepared which will not rust on prolonged exposure to air or water, and will not cause the deposition of copper from its solutions. It has been thought that any electrolytic theory of the rusting of iron must stand or fall on the question of the solubility of pure iron in pure water, but since the solution of a metal in an electrolyte depends upon the existence of p.d.'s and consequent flow of current it follows that a chemically pure and physically homogeneous metal cannot rust because there is no variation in solution pressure over the whole of its surface so that

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no p.d.'s can be set up. At the same time it also follows that the production of a coherent uniform coating on the surface of commercial iron would prevent rusting. Corrosion can be started in iron which does not rust by locally deforming it, when the deformed portion becomes electronegative. The behaviour of pure iron towards copper chloride solution is of interest since it cannot be predicted by the electrolytic theory. Pure iron which does not rust in water and does not precipitate copper from copper nitrate and sulphate solutions, immediately precipitates copper from copper chloride solution. A similar effect is brought about by adding chlorides of the alkali metals to solutions of copper nitrate or sulphate containing bright iron, or by heating sulphate solution to 100°C. Dilute solutions of the chlorides of the alkali metals have a remarkable effect in starting the corrosion of pure iron. The author considers that passivity is brought about by such materials as strong nitric acid or caustic alkalies having the power to destroy or seriously diminish the electrical differences which always occur in commercial iron, with the production of an "electrically equable surface." On the other hand, such materials as chlorides stimulate corrosion by increasing the electrical differences.

F. C. A. H. L.

1910. Potential due to Liquid Contact. A. C. Cumming and E. Gilchrist. (Faraday Soc., Trans. 9, pp. 174-185, July, 1918.)—The authors' experiments lead them to the following conclusions:—(1) To obtain accurate measurements of potential it is necessary to form a new boundary shortly before the measurement is taken, otherwise a serious error may be introduced. (2) It is desirable that the two solutions should be mechanically mixed at the boundary, and this is the more important the narrower the tube in which the boundary is formed. (3) Capillary tubes should be altogether avoided in the construction of an electromotive cell. (4) The e.m.f. of any cell which derives part of its potential from the presence of a liquid contact is not constant, but varies with the time which has elapsed since formation of the boundary; if due attention is paid to the precautions mentioned above, consistent and comparable results may be obtained.

L. H. W.

1911. Measurement of Polarisation; Methodical Error. D. Reichinstein. (Zeitschr. Elektrochem. 19, pp. 518-520, July 1, 1918.)—In his measurement of the chemical polarisation of the reversible electrode $\text{Cu} \mid \text{Cu}^{++}$ the author had made use of a Pt-H_2 -electrode, the siphon of which ended at the paraffined back of the electrode. F. Foerster having drawn his attention to the fact that this method was misleading, he continues his researches with the aid of the Haber-Luggin capillary. He further points out that a real alloy will, when not under current, have practically the potential of the principal metal, which metal will alone be dissolved with anodic polarisation. Such an alloy will show the properties of a reversible electrode in an accentuated degree.

H. B.

1912. Chemical Polarisation of Reversible Electrodes. Anodic Behaviour of the Alloys Hg-Cu and Ag-Cu . D. Reichinstein [Experiments with A. Bürger.] (Zeitschr. Elektrochem. 19, pp. 520-530, July 1, 1918.)—The author distinguishes between positive depolarisation (when the addition of the depolariser increases the current intensity) and negative depolarisation (when the current intensity is decreased). The depolarisation is due not to a difference in the equilibrium potentials of two systems, but to special kinetic conditions; the mechanism is somewhat as in auto-catalytic reactions. The anodic dissolution of a reversible electrode is of the nature of a negative

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depolarisation. The experiments concern the current density-potential curves and the time-potential curves of anodically polarised electrodes, $\text{Cu} \mid \text{CuSO}_4$, $\text{Cu-Hg} \mid \text{CuSO}_4$, $\text{Cu-Ag} \mid \text{CuSO}_4$, in the presence of H_2SO_4 . Primary copper-ions are formed as the formation of the alloy Hg-Cu proceeds; the pure copper electrode itself behaves qualitatively like a real alloy of Cu-O . H. B.

1913. *Overvoltage*. J. W. Richards. (Faraday Soc., Trans. 9. pp. 140-141, July, 1918.)—The author regards overvoltage as due to increased surface resistance caused by the adhesion of gas to the metal. Support of this view he finds in three experiments made with sulphuric acid cells and smooth electrodes of Pt, Au, or Ni, the cell being treated as a calorimeter. H. B.

1914. *Electrolytic Valve Action of Niobium*. U. Sborgi. (Gazzetta Soc. Chim. Ital. 42. 2. pp. 881-845, 1912.)—The anodic behaviour of niobium in various electrolytes is found to depend on its degree of compactness, a momentary current being produced in most electrolytes with an anode of incompact Nb, but no current passing when a compact block of Nb is used. It is concluded that the anode becomes covered at the commencement of electrolysis, with a layer which hinders the passage of ions, its degree of impermeability varying in different electrolytes. Niobium differs from ordinary passive metals in these respects, and also in dissolving when a current passes. [See also Abstract No. 1019 (1908).] W. H. St.

1915. *The Form of Electrolytically Deposited Metals*. I. *Black Silver*. V. Kohlschütter and T. Toropoff. (Zeitschr. Elektrochem. 19. pp. 161-168, Feb. 15, 1918.)—Silver black differs from other black metals. It can be obtained by the action of organic reducing agents and of Zn, Cu, Cd on solutions of silver salts, and further by electrolysing diluted solutions at high current density. However prepared, black silver cannot be isolated as such, because it changes into the grey or white crystalline metal; the change sets in as soon as the current is interrupted, and takes place more rapidly in acid and also in alkaline solutions than in pure water. Itself crystalline and yet colloidal, the black silver seems to be in a state intermediate between the colloidal and the crystalline states. The crystallisation is studied with the aid of potential measurements on small cathodes and large anodes. The formation of black silver occurs when the very diluted solution at high-current density is, so to say, supersaturated with silver atoms near the small cathode. The sudden change on stopping the current is supposed to be an electrostatic phenomenon.

II. *Silver Deposited by Metals*. V. Kohlschütter, T. Toropoff, and W. Pfander. (Ibid. pp. 169-172, Feb. 15, 1918.)—The appearance of the silver depends upon the concentration of the solution, on the rate of precipitation by the metals studied, Cu, Zn, Cd, Fe, Sn, Al, Mg, and upon their chemical behaviour. The addition of salts to the silver nitrate, strange to say, accelerates the deposition. When copper is placed in silver nitrate and some neutral copper sulphate is added, colloidal copper hydroxide is formed by hydrolysis and adsorbed by the copper, whose solution is thus retarded; but in the presence of the electrolyte the colloidal film is either dissolved or coagulated. The colloidal hydroxide has, however, some influence on the crystallisation of the silver.

III. *Influence of Foreign Substances on the Deposition of Silver*. V. Kohlschütter and H. Schacht. (Ibid. pp. 172-181, Feb. 15, 1918.)—When
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the ammoniacal solution of silver nitrate contains also small quantities of salts (nitrates) of Cu, Zn, Cd, Pb, Be, Cr, Al, Tl, colloidal hydroxides are formed which affect the silver electrolytically deposited, as is demonstrated by photomicrographs. Strangely enough, the silver deposits are, as a rule, heavier than they should be, apparently because silver is also precipitated chemically, not only electrolytically; compounds of the other metals are also found in the deposit, but only in traces. The hydroxide films on the kathode act as filters which influence the distribution of the germs or centres of crystallisation.

IV. *Electrolytic Deposition of Silver from Complex Salt Solutions.* V. Kohl-schütter. (Ibid. pp. 181-184, Feb. 15, 1918.)—Complex (cyanides, thio-sulphate, oxalate, etc.) solutions deposit in the first instance colloidal "sub-haloids" or "photo haloids" of reddish-violet or blue-grey colour. This deposit forms a skin or film which changes its colour into silver-white when it is washed with water, especially in faintly alkaline solutions. When the electrode together with the skin is washed and immersed in ammoniacal silver nitrate, the silver is deposited as a coherent adhesive layer on the skin, as if the solution were still of the complex character. If the silver kathode is itself dissolved in nitric acid, the skin or film remains intact, and silver will be deposited on it again in the compact form, not in crystal groups. The experiments do not suffice to explain the phenomena. H. B.

1916. *Electrolysis of Nitric Acid Solutions of Copper.* J. H. Stansbie. (Faraday Soc., Trans. 9. pp. 11-18, July, 1918. Chem. News, 106. p. 288, Dec. 18, 1912.)—The author's experiments were made with the object of finding the cause of the failure of the electric current to deposit copper completely from nitric acid solutions of the metal. It was found that when a Pt kathode, thickly plated with copper, was rotated in a solution of nitric acid containing less than 0.1 mgm. of copper, no current being passed, much less copper was dissolved than when the electrode was stationary. In the latter case the nitrous acid or nitrite accumulates in the neighbourhood of the copper and thus exerts its solvent action. In experiments on the deposition of Cu from nitric acid solutions the amount of Cu left in the solution was found to increase with the concentration of the nitric acid and with the accumulation of nitrous acid in the solution. The presence of free sulphuric acid in the solution prevents the formation of nitrous acid, and hence its beneficial effect on the quantitative deposition of Cu from solutions containing nitric acid. T. S. P.

1917. *Passivity of Metals and its Dependence upon the Solvent.* N. Isgarischemw. (Zeitschr. Elektrochem. 19. pp. 491-498, June 15, 1918.)—The experiments were made by taking potential measurements of various metals—Ni, Co, Fe, Cd, Cu, Zn—in their salts dissolved in alcohols or in water. The nickel, e.g. was tested in nickel chloride; the potential rose, went back to its original value on removing the nickel (when the electrode was taken out of the bath and cleaned), rose more rapidly again on second immersion, and so on. When all the oxygen had been removed from the electrolyte and hydrogen was passed through it while taking measurements, the potentials did not rise. The rise of potential or passivity is hence ascribed to the formation of an intermediate soluble product, probably a peroxide. Copper seems to form a complex compound containing its chloride and alcohol of the formula $\text{Cu} \cdot (\text{C}_2\text{H}_5\text{O})_2 \cdot \text{CuCl}_2$. H. B.

1918. *Tantalum as Kathode Material.* G. Oesterheld. (Zeitschr. Elektrochem. 19. pp. 585-587, Aug. 1, 1918.)—O. Brunck having recommended kathodes of tantalum, which is not attacked by aqua regia and caustic alkalies, the author investigates its behaviour in electrolysis. The metal foil loses its elasticity and strength in a few hours in alkaline and acid solutions, because it readily adsorbs hydrogen, and 0.1 per cent. of hydrogen is sufficient to change the structure of tantalum. Comparison experiments were made with palladium. H. B.

1919. *Influence of Colloids on the Electrolysis of Metallic Salts (Lead and Zinc).* I. R. Marc. (Zeitschr. Elektrochem. 19. pp. 481-444, June 1, 1918.)—The colloids added in small quantities are gum arabic, starch, albumin, and gelatin, the salts the acetate, formate, benzoate, salicylate and silicofluoride of lead, and the acetate and silicofluoride of zinc. Both the kathode and the anode products are studied. All the colloids tend to produce a finer grain of the kathode deposit, but the coherence may be improved or deteriorated: two effects oppose one another. A coherent layer requires high elasticity and small grain; but a pure solution generally confers the former, not the latter property, and where there is a tendency to form large crystals, the addition of comparatively large amounts of colloids leads to brittleness. Brownian movements were observed in the case of lead crystals of unusually large dimensions, 15 by 2 μ , but extremely thin, when colloids were present, not in pure water; this persistence of Brownian movements was also observed with barium and strontium salts (sulphate and carbonate), in the presence of colloids. At the kathode the presence of colloids always favoured the liberation of hydrogen; their influence upon the reactions at the anode was complex, lead peroxide being deposited, oxygen liberated, or incrustations of organic compounds being formed. Photographs of characteristic deposits are reproduced in the paper. H. B.

1920. *Electrolytic Separation of Tin from Tungsten.* W. D. Treadwell. (Zeitschr. Elektrochem. 19. pp. 881-884, May 1, 1918.)—Having reviewed the chemical methods, the author shows that tin may be electrolytically deposited from solutions in sodium sulphide; ammonium sulphide is not advisable because the deposit is contaminated with sulphur and may contain up to 2 mgm. of Pt. Even in the former case some sulphide is always found in the deposit, and the current should be interrupted a few mins. after the precipitation of the tin may be assumed to be complete. Any Mo present would fall together with the tin; when oxalic acid is used as solvent, W would also go into the deposit. The electrolytic separation, particulars of which are given, is much more expeditious than gravimetric methods. H. B.

1921. *Electrochemical Production of Colloidal Copper.* T. R. Briggs. (Journ. Phys. Chem. 17. pp. 281-319, March, 1918.)—The general results are the following:—(1) Schützenberger's "allotropic" copper is a solid gel of normal copper in a finely-divided form, analogous to similar forms of lead, silver, and gold. (2) The electrolytic production of a new form of colloidal copper by the electrolysis of certain copper solutions containing gelatine is described in detail. (3) The remarkable colour action shown by these films of gelatine-copper has been studied and is termed a development. (4) Electrolytic methods have been devised for colouring objects of copper and other metals a variety of hues, the more prominent being blue, red, and gold.

L. H. W.

SCIENCE ABSTRACTS.

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Section A.—PHYSICS.

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GENERAL PHYSICS.

1922. *A Quartz Pendulum.* M. Schanzer. (Zeitschr. Instrumentenk. 88. pp. 277-279, Sept., 1918.)—It is claimed that vitreous silica has advantages over invar as the material for the shaft of a standard pendulum. The details of construction of such a pendulum are given. P. E. S.

1923. *A Fuller Test of the Law of Torsional Oscillation.* J. B. Ritchie. (Roy. Soc. Edinburgh, Proc. 88. pp. 177-182, 1912-1918.)—Examines the effect of modifying, by a closer approximation, the equation $y''(x+a)=b$, which represents the law of decrease of torsional oscillations in wires [see Abstract No. 1810 (1911)]. On plotting results for Cu a curve of form similar to that given by the original equation is obtained, and it is concluded that no improvement is introduced by taking the more accurate form. J. W. T. W.

1924. *Continued Investigation of the Application of the Law of Torsional Oscillation.* J. B. Ritchie. (Roy. Soc. Edinburgh, Proc. 88. pp. 188-198, 1912-1918.)—Describes a continuation of former experiments [see Abstract No. 1810 (1911)] made upon eight metals: brass, Au, Pt-Ir, Pt, assay silver, Al, Cu, and German silver. Three alloys of Cu and Al satisfied the general equation [see preceding Abstract], while one of Al and brass was found which did not change its behaviour after heating. Magnetisation of an iron wire produced a gradual but irregular increase in one only of the constants for the wire. A compound wire (Zn electrolytically deposited on Cu) gave results lying between those for the constituent metals. J. W. T. W.

1925. *Deviation of the Torsional Oscillations of Metallic Wires from Isochronism.* W. Peddie. (Roy. Soc. Edinburgh, Proc. 88. pp. 225-242, 1912-1918.)—In former papers (Ibid. Trans., 1898; Phil. Mag., 1894) it was shown that the period of the inward oscillation of an iron wire was distinctly greater than the period of its outward oscillation over the same range, and that the complete period was slightly greater when the range was relatively great than when it was small. In these respects the material deviated from

the conditions of isochronism that are characteristic of the simple harmonic vibrations of a material which practically follows Hooke's law during distortion. Since the method of observation formerly employed did not give much more than qualitative results and was quite inadequate for the determination of the actual law of oscillation at all stages, a different method has been employed in the work which constitutes the subject-matter of the present paper. A description of the method and of the apparatus is first given at some length, accompanied by diagrams and curves whereby the experimental results are shown for the cases of three different materials, viz. iron, copper, and zinc, and the nature of their deviation from those characteristic of simple harmonic motion is exhibited. The correspondence of the small oscillations of an elastic material, such as steel, with the simple harmonic law is well known, but it seems to be a very remarkable thing that, in the case of a substance possessing so great viscosity (the term viscosity being used here merely to indicate internal resistance to relative motion of the parts) that the amplitude falls to one-half of its initial value in a single semi-oscillation, the law of oscillation should be very accurately simple harmonic from the extremity of the range inwards to the position of set (inflection), beyond that to the zero point, and almost as far beyond the zero on the negative side as the position of set is separated from it on the positive side. After that stage is reached, the deviation from the simple harmonic law takes place very rapidly. The result is very significant in connection with the view of G. Wiedemann, that the loss of energy is due to the work done in shifting the position of set from one side of the zero point to the other. Its possibility was suggested by the theoretical discussion which the author next gives of a molecular condition under which the observed laws of torsional oscillation might be simulated. This theoretical treatment is based upon the experimental results and the established fact that the law of the decrement of the range, y , of oscillation, as the number of oscillations, x , increases, is very accurately given by the relation $y^n(x+a)=b$, where n , a , and b are constants, together with other known facts regarding the statical and kinetic laws of deformation of a solid, e.g., those of "set." Any theory must be of "molecular" type, the loss of energy being, in great part at least, due to the rupture of molecular configurations, which latter may take place on a finite "crystalline" scale. The author summarises the results of his investigations as follows:—(1) The oscillations of a viscous wire exhibiting set are simple harmonic with regard to the position of set throughout the whole range of the in-motion and a considerable part of the out-motion. In the remainder of the out-motion the deviation from the simple harmonic condition is great. (2) The period of in-motion to the zero is distinctly greater than that of the out-motion from it. (3) A theoretical deduction of these results, and of the law of loss of energy per oscillation, can be founded on the assumption that that loss is due to the rupture of strained molecular (which may be finite crystalline) groups. (4) A sudden change in the oscillation parameters when the decreasing maxima pass through a definite magnitude is explainable by the existence of a dominant type of groups which cease to rupture when the decreasing strain reaches a definite value; and the known peculiar temperature and stress effects are explainable as depending on well-recognised conditions of structural changes.

H. H. HO.

1926. *Strength of Hooks and Curved Beams*. (Engineering, 96, pp. 307-309, Sept. 5, 1918.)—The mathematical investigation of the stresses in hooks and
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curved beams published by E. S. Andrews and K. Pearson in a Drapers' Company Research Memoir, 1904, is criticised on account of the extreme complexity of the formula attained, and because this formula does not appear to give very accurate results for the stresses. The complete argument would be useless if materially abbreviated, but the principal assumption wherein lie the differences between the present discussion and that of Andrews and Pearson is that those authors assumed that stresses which were zero at the surface of the beam were zero throughout the section; this it is shown is not true, because the radial stress attains a value which may be considerable when the ratio of the inner to the outer radius, r_0/r_1 , is small. Instead the convenient assumption is made that the contribution of these transverse stresses to the resilience of the beam is practically constant for all reasonably probable distributions of the tangential stresses. The resulting approximation is $Q = k + l/r$, for the tangential stress, Q , which, as a table shows, gives much closer results than the formula of Andrews and Pearson; k and l are determined by the relations $k\bar{r} + l = M/\Omega$, and $k\Omega + l \int_{r_0}^{r_1} z/r \cdot dr = 0$. The integral $\int z/r \cdot dr$ is found for any section graphically or by other approximate method, Ω is the area of cross-section, \bar{r} the distance of its centre of gravity from the centre of curvature, z is the breadth of the layer at radius r , M is the bending moment.

F. R.

1927. *Viscosity of Anisotropic Liquids*. F. Krüger. (Phys. Zeitschr. 14, pp. 651-655, July 15, 1918.)—Anisotropic liquids and emulsions show a complete mutual analogy in the dependence of their viscosity upon pressure. Since no molecular peculiarities would account for this analogy [see Bose, Abstract No. 208 (1909)], it must be inherent in liquids generally. Sorkau distinguishes three states of turbulence, which Mie has shown to be reducible to two. In the normal viscous flow (Poiseuille) the temperature coefficient of viscosity is characteristic for each substance. In the first turbulent state (Reynolds) the temperature coefficient is nearly the same for all substances, while in the second turbulent state, in which the liquid passes through the capillary like a solid rod covered by a liquid film, there is practically no change with temperature. Bose's "swarm theory" may be a true statement of many molecular facts, but it cannot now be called upon to explain the dependence of viscosity upon pressure.

E. E. F.

1928. *Determination of Capillary Constant in Molten Solids by Means of Dimensions of Drops*. A. Ignatiev. (Jurn. Russk. Fizik.-Chimičesk. Obščestva, 44. 2. pp. 71-78, 1912.)—Finding Kasterin's formula (Ibid. 25. p. 208, 1898) imperfect, the author used the following:—

$$a^2 = \frac{1}{2}h^2 - d \cdot a^2 h/L + 2a^2 h/b,$$

where a^2 capillary constant, h = vertical distance between summit and greatest horizontal section of drop, $2L$ = greatest drop diam., b = radius of drop at summit, d = const. = 0.61.

$$a^2 = \frac{1}{2}h^2 / [-h(2/b - d/L)] = \frac{1}{2}h/1.$$

b is taken as $= \frac{1}{2}(u/z)$, where u and z are the co-ordinates of points in the drop's outline near its summit. Experiments were carried out as follows:—On an horizontal table 12 pieces of glass were placed on which 12 lumps, of different dimensions, of the materials were put (after being cooled down and split).

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Between the lumps of material on the glass were put up rods, the heights of which were correctly measured. The material melted on the glass and took the form of flattened drops. These drops were then photographed together with the rods. With a dividing machine and microscope the distance (h_1) from the summit of the drops to the greatest horizontal section was determined, also the measurement of the rods. From the correct heights of the rods a true scale of photograph was determined with a correct calculation for h . In the same manner also $2L$ was determined. To correctly define b the co-ordinates u and z for the different drops were determined by projecting a greatly enlarged image of the outline of the drops. The average value obtained for a^2 is 5.60 ± 0.05 , comparing with Landolt and Börnstein's tables, showing:—

	a^2 .	b^2 .
Spermaceti	7.9	44
Sweet oil	7.8-7.7	20
Wax	7.1	68
Petroleum.....	6.5	25
Turpentine... $\left\{ \begin{array}{l} s = 0.89 \\ s = 0.98 \end{array} \right.$	$\left\{ \begin{array}{l} 6.1 \\ 5.8 \end{array} \right.$	$\left\{ \begin{array}{l} 20 \\ 20 \end{array} \right.$

The temperature during the duration of test ranged between 14° and 24° .

I. P.

1929. *Experiments with Rotating Liquid Films*. C. V. Boys. (Roy. Soc., Proc. Ser. A. 87. pp. 840-850, Oct. 2, 1912.)—A description of a number of beautiful experimental effects obtained with the aid of an apparatus consisting of a rotating cylindrical cup with inturned rim, on which a soap film is stretched. The apparatus is the same as that now being sold under the name of the "Rainbow Cup," and a fuller account is to appear in the form of an additional chapter to the author's book on "Soap Bubbles." L. H. W.

1930. *Constitution of Atoms and Molecules*. N. Bohr. (Phil. Mag. 26. pp. 1-25, July, 1918.)—The starting-point of this inquiry is Rutherford's hypothesis of atomic constitution [Abstract No. 1847 (1911)]. In Thomson's atom-model the radius of the sphere of positive electrification provides a constant having the dimensions of a length, and of the same order of magnitude as the linear extension of the atom, and so the model allows of certain stable configurations and motions. The author's primary aim is to show that the introduction of Planck's constant, the elementary quantum of action, will serve, in Rutherford's model, to take the place of the radius of the positive sphere, and so make stability possible.

First consider a single electron, negligibly small compared with the positive nucleus, and with a velocity small compared to that of light. Let $-e$ be the charge of the electron, m its mass, and E the charge of the nucleus. If no radiation the orbit will be a stationary ellipse with frequency ω and semi-major axis a , such that $\omega = \sqrt{2/\pi} \cdot W^{1/2}/eE\sqrt{m}$, $2a = eE/W$; where W is the energy required to separate the electron to an infinite distance from the nucleus, which can be shown to equal the mean kinetic energy of the electron taken for a whole revolution. Taking account of radiation, W will continually increase and a diminish, while ω will increase, the electron gaining in mean kinetic energy as the whole system loses energy. This will continue until the dimensions of the orbit are of the same order of magnitude as those of the electron or of the nucleus, and during its continuance the radiation is enormously greater than in ordinary molecular

processes. Assume that the reaction between nucleus and electron started at a great distance apart and with no sensible relative velocity, and that when complete the orbit is stationary and circular. Assume further that during this binding of the electron the radiation is homogeneous and of frequency ν , equal to half the final revolution frequency as suggested by the initial revolution frequency being 0. Then, on Planck's theory, the energy emitted during the process should be $\tau h\nu$, where τ is an integer, and h is Planck's constant. Then, substituting $W = \tau h\omega/2$, we have—

$$W = 2\pi^2 m e^2 E^2 / r^2 h^2, \quad \omega = 4\pi^2 m e^2 E^2 / r^3 h^3, \quad 2a = r^2 h^2 / 2\pi^2 m e.$$

W will then be greatest, and the system most stable, for $r = 1$. Substituting this, the experimental values for e , e/m , and h , and putting $E = e$, we get—

$$2a = 1.1 \times 10^{-8} \text{ cm.}, \quad \omega = 6.2 \times 10^{15} \text{ (sec)}^{-1}, \quad W/e = 18 \text{ volts},$$

which are of the same order as the linear dimensions of the atoms, the optical frequencies, and the ionisation potentials respectively.

The author briefly criticises the atomic systems proposed by J. W. Nicholson in view of Planck's theory [Abstracts Nos. 155, 449, 1648, 1644 (1912), and 865 (1913)], stating that, apart from objections which may be only formal, they do not appear capable of accounting for the laws of Balmer and Rydberg connecting the frequencies of the lines in the line spectra of the ordinary elements, and claims that his theory provides a solution, and further, that his special assumptions may be modified, retaining the fundamental ones:—that the dynamical equilibrium of the systems in the stationary states can be discussed in terms of the ordinary mechanics, but not so during passage between two such states; and that such a passage is followed by the emission of homogeneous radiation for which the relation between the frequency and the energy emitted is that of Planck's theory. General evidence indicates that the atom of hydrogen is of the kind considered above, and here $W_r = 2\pi^2 m e^4 / h^2 r^2$, so that equating the energy emitted in passing from r_1 to r_2 to $h\nu$ gives $\nu = 2\pi^2 m e^4 / h^3 \cdot (r_1^{-2} - r_2^{-2})$. This gives the Balmer series for $r_2 = 2$, while r_1 varies. $r_2 = 3$ gives the series in the ultra-red suspected by Ritz and observed by Paschen [Abstract No. 285 (1909)]. $r_2 = 1, 4, 5$, gives series in the extreme ultra-violet and ultra-red, which have not been observed, but the existence of which may be expected. And the agreement is quantitative as well as qualitative, for, by calculation, $2\pi^2 m e^4 / h^3$ has the value 8.1×10^{15} , while the observed value is 8.290×10^{15} , a difference within the limits of experimental error in determining the constants in the theoretical expression. Moreover, the theory shows that small gaseous density is essential to appearance of many lines, and simultaneously to obtain an intensity sufficient for observation the volume of gas available must be very great, which would explain why 88 Balmer lines are observed in some celestial spectra, and not more than 12 in vacuum tubes.

The lines observed by Pickering and Fowler, and generally attributed to hydrogen, are not accounted for, but the author shows that they could be accounted for as arising from helium, and suggests that this may be the case. For systems containing more than one electron the detailed discussion will probably be very complex, but the frequency being expressible as a difference between two functions of integers suggests an origin of the spectra similar to that assumed for hydrogen. Moreover, the presence of the universal constant K in Rydberg's formula will follow for a spectrum corresponding to radiation

emitted during the binding of an electron, provided the system, including that electron, is neutral, for in that case for high values of r ,

$$\text{Lim}(r^2 \cdot F_1(r)) = \text{Lim}(r^2 \cdot F_2(r)) = \dots = 2\pi^2 mc^2/h^2.$$

The assumption hitherto made that different stationary states correspond to different numbers of energy quanta is improbable, for the frequency is a function of the energy and will therefore be changed by emission of a quantum, and the author shows that the results are unchanged when the equation $W = rh\omega/2$ is interpreted as meaning that the frequency of the energy emitted during the passing of the system from a state of no radiation to one of the different stationary states is equal to different multiples of $\omega/2$. Further, the values for W , ω , and a , provided the electron orbit be circular in a stationary state, merely express the condition that in such a state the angular momentum of the electron round the nucleus is an integral multiple of a universal value, independent of E . The permanent state is then that for which $r = 1$. To account for Kirchhoff's law in radiation during passage between stationary states A_1 , A_2 , the necessary conditions for such emission is the presence of systems in state A_1 , and for absorption, the presence of systems in state A_2 . This agrees with experiment, *e.g.*, absence of absorption of line spectrum radiation in hydrogen, for emission was found to occur in passages for which $r \geq 2$, while the permanent state is for $r = 1$, and the author shows how other experimental results are accounted for.

Rutherford's calculations of energy of β -particles [Abstract No. 488 (1918)] suggest that an electron traversing an atom at high velocity liberates energy in quanta in collisions with the electrons of the atom, and the absence of equipartition of energy between free electrons and those bound in atoms demands explanation. This we find, with that of Rutherford's results, in the assumption that two colliding electrons, bound or free, will, after collision as before, be in stationary, or *mechanical*, states. The bound electron could not, therefore, acquire less than the difference in energy corresponding to successive stationary states, and so the free colliding electron could not lose less.

The small dissociation of hydrogen molecules at ordinary temperatures necessitates consideration of more complex molecules for further comparison with experimental results. The author then shows that to proceed from system of single electron in circular orbit to ring of n electrons we merely have to substitute $E - es_n$ for E , where—

$$s_n = \sum_{s=1}^{s=n-1} \text{COSEC } \frac{s\pi}{n}.$$

Then, assuming the binding of the electrons to come about as before, the configuration for greatest energy emission will again be for $r = 1$, to be taken as the permanent state. The author considers that line spectra of systems with more than one electron require existence of states brought about also in other ways, but none corresponding to greater energy emission than the one here taken as permanent. Stability is assumed to be secured through the universal constancy of the angular momentum, together with the assumption that the configuration is that in formation of which most energy is emitted, which is found equivalent to that ordinarily made so far as displacements perpendicular to the plane of the ring are concerned. The difference in the laws of ordinary line spectra and those found by Nicholson for coronal spectra may arise from the latter being due to scattering, and not true

emission, of radiation—a natural assumption since the extreme rarefaction would result in few collisions to disturb the stationary state.

The author then enunciates, as capable of simple proof, the theorem :—
 “In every system consisting of electrons and positive nuclei, in which the nuclei are at rest and the electrons move in circular orbits with a velocity small compared to the velocity of light, the kinetic energy will be numerically equal to half the potential energy.” Hence he generalises his atomic hypothesis into the form :—In any molecular system consisting of positive nuclei and electrons in which the nuclei are at rest relative to each other and the electrons move in circular orbits, the angular momentum of every electron round the centre of its orbit will in the permanent state of the system be equal to $h/2\pi$, where h is Planck's constant.

G. W. DE T.

1931. *Determination of Aqueous Vapour above Mount Wilson.* F. E. Fowle. (Astrophys. Journ. 37. pp. 359–372, June, 1918.)—The amount of aqueous vapour in the atmosphere was determined by the spectro-bolometric method described in an earlier paper [see Abstract No. 1525 (1912)]. The experiments discussed in the present paper were made on certain days in the years 1910 and 1911. The average quantity of precipitable water present was 0.69 cm., with a range from 0.2 cm. to 2.8 cm. Hann gives the formula $Q_w = 2.8e_w$, connecting the vapour pressure e_w , at the earth's surface with the depth of precipitable water in the atmosphere, Q_w . Correcting this for the altitude of Mount Wilson above sea-level (1730 m.) the formula becomes $Q_w = 1.9e_w$. Humphreys finds a value of 1.7 for this constant. The mean value from the present author's experiments is 1.8, but individual values vary from 0.8 to 11.8; so that the formula, though applicable to mean conditions, cannot be regarded as of any value for individual days.

J. S. DI.

1932. *Difference of Temperature between the Free Air and the Air on Mountain Summits.* H. v. Ficker. (Meteorolog. Zeitschr. 30. pp. 278–289, June, 1918.)—The summit taken for the comparison is Zugspitze (2964 m. above sea-level). Observations of free air temperatures were derived either from results of ascents of manned balloons starting from Innsbruck or from ascents of registering balloons from Munich. The results of the comparisons are : (1) At 7 a.m. the Zugspitze is always colder than the free atmosphere at the same height. At 2 p.m. the difference is nil or very small. (2) The differences are least in calm weather. (3) The result of the comparison cannot be taken as applying to the whole of the Alpine mountain-peaks without further investigation. (4) With an upward current the difference is small if condensation is taking place at the Zugspitze level; otherwise it is greater. Rising currents are usually associated with winds having northerly components on account of the main mass of the Alps lying to the south. (5) The difference is greatest with a downward current, i.e. with a wind having a southerly component.

R. C.

1933. *Studies of the Nocturnal Radiation to Space.* A. Ångström. (Astrophys. Journ. 37. pp. 805–821, June, 1918.)—The paper has four parts : (1) An historical review of the subject. (2) Theoretical considerations. (3) An account of the instrument used by the author in his experiments, and (4) A discussion of the results obtained. Little work has been done on the outward radiation to space in comparison with that which has been devoted to the incident solar radiation, so that present knowledge of the subject is

very incomplete. The observations of the author were made on the loss of heat of a black body exposed at night to the complete hemisphere of the sky. It is pointed out that this is made up of the outward (positive) radiation to space determined by Stefan's law, together with the inward (negative) radiation from the gases of the atmosphere and sidereal sources. The instrument employed was a suitably modified form of the well-known Ångström pyrheliometer. The loss of heat (R) in cal. per cm.² per min. from a black body freely exposed at night at Bassour, Algeria, was found to be connected with the surface vapour-pressure p (mm.) by the equation $R = 0.109 + 0.184e^{-0.10p}$. This equation may not hold without modification for temperatures which differ widely from those experienced at the time and place of these experiments.

J. S. DI.

1934. *Air in the Depths of the Ocean*. C. Juday. (Science, 88, pp. 546-547, Oct. 17, 1918).—The author commences by pointing out that the suggestion in recent communications on this subject as to diffusion being the sole agent involved in the aeration of ocean depths is untenable, since it only plays a negligible rôle. The atmospheric gases only diffuse very slowly through water, the coefficient of nitrogen being 1.78, of oxygen 1.62, and of CO 1.88, while the rapidity with which oxygen is transferred is well illustrated by Hüfner's computations for Lake Constance which has a max. depth of about 250 m. The latter are: (1) That it would take oxygen about 42½ years to pass from the surface to the bottom by diffusion alone; (2) that over 100,000 years are required for the quantity of oxygen which its waters are capable of holding at 10° C. to diffuse into a body of water of equal area and unlimited depth; (3) that under natural conditions, with the depth limited to 250 m., it would require over a million years for this body of water to become saturated at the above temperature if it had no dissolved oxygen and acquired a supply only by diffusion from the atmosphere. Again, if ocean waters were aerated solely by diffusion the upper strata should possess a larger amount of dissolved oxygen than the lower, which is not actually the case. Other examples are quoted to illustrate the fact that some other agent than diffusion is responsible for the aeration of bodies of water. The author suggests that in lakes aeration is accomplished by the vernal and autumnal overturning of the water and its subsequent circulation for a longer or shorter period. In the case of ocean waters Helland-Hansen states that "gases are absorbed at the surface from the atmosphere and are carried by currents even into the deepest parts of the ocean in varying amounts."

H. H. HO.

1935. *Solar Magnetism*. K. Birkeland. (Comptes Rendus, 157, pp. 104-106, July 15, 1918).—The author sets out to prove that the emission of ions and electrons from the sun produces an increase of solar magnetism up to a certain point, and that the field may either have the sense of the earth's direction, or, as the author has deduced [see Abstract No. 448 (1910)], the converse sense. He takes the case of a magnetic sphere emitting corpuscular radiations, where from polar regions the radiation may escape to infinity by passing sufficiently near the lines of magnetic force, while equatorially the magnetic force is normal to the orbit of the radiated corpuscles, and, unless certain conditions are present, the latter are incapable of escape. A mathematical analysis then gives the very simple result that if the radiation emanating from the spherical surface in the plane of its magnetic equator and subjected only to the magnetic influence of the sphere, exceeds a distance

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greater than 2·414 times the radius, this radiation can never return to the sphere, but is directed towards infinity. This result is independent of the magnetic moment of the sphere and the magnetic rigidity of the corpuscular rays. Some exhaustive researches upon magnetic storms and polar aurora have shown that precipitations of helio-kathodic rays exist in the maximum belt of the aurora. A discussion of Schuster's work on this question then follows. The author has performed experiments with a magnetic globe which have verified the above theoretical treatment. From the experiments came the conception that there are currents circulating round the sun at a relatively small distance outside, which play a very prominent part in solar magnetism and constitute its primary cause. The movements of sun-spots also appear to require for their explanation that solar magnetism may vary periodically, with a minimum in the year of minimum spots. H. H. HO.

1936. *Photographs of the Aurora Spectrum*. L. Vegard. (Phys. Zeitschr. 14. pp. 677-681, Aug. 1, 1918.)—According to Störmer's calculations, the daily variation of the aurora polaris may be used to determine the deflectibility of the solar discharges giving rise to it. The author prefers to draw conclusions from the structure and the spectrum of the aurora [Abstract No. 868 (1912)]. The structural evidence favours an α -rays cause. Spectrum photographs were obtained at Bossekop, Finmarken, in the course of the three months ending the year, 1912, with sufficient dispersion to reduce the error of the brighter lines to half an Ångström unit. The three strongest lines thus measured are at 4708·0, 4278·0, and 8914·6. Fainter lines are at 5571·8, 4646·8, 4234·2, and 4200·8. All the lines except the greenish-yellow 5571·8 correspond to heads of nitrogen bands as produced by the impact of α -rays. The line 5571·8 is near the strong argon line 5572·6. The results favour the view that the aurora is produced by the impact of solar α -particles upon nitrogen molecules. E. E. F.

1937. *Radial Velocities of Vapours in Sun-spots*. C. St. John. (Comptes Rendus, 157. pp. 428-480, Sept. 1, 1918.)—The investigation of the radial motion of sun-spot vapours, tangential to the solar surface, first announced by Evershed in 1909, has been continued with the tower telescope at Mount Wilson; and several striking results are summarised. (1) The displacements are proportional to wave-lengths, showing the phenomenon to be a motion effect. (2) If the lines of iron are grouped in order of their intensity in the Fraunhofer spectrum, the displacements appear to be decidedly in the opposite relation, i.e. the *weaker* lines have the *greater* displacements. The sign of the displacement is positive, indicating a movement of the vapour from the centre to the outer boundary of the spot. The strongest lines appear to have very little displacement. (3) These differences are interpreted as indicating a vertical distribution of the vapours producing the lines of different intensity. (4) The resulting distribution is such that H_α and K_2 of calcium are emitted at a higher level than H_α of hydrogen, and that H_α is between the levels of K_2 and K_1 . This is in accordance with the conclusions published by Deslandres from a study of spectroheliograms taken at Meudon. C. P. B.

LIGHT.

1938. *New Types of Spectrophotometer on the "Flicker" Principle.* J. R. Milne. (Roy. Soc. Edinburgh, Proc. 88. pp. 257-268, 1912-1918.)—In a previous paper [Optical Convention, Proc. p. 178, 1905] the author described a new form of spectrophotometer in which the comparison of relative brightness is affected by bringing the two beams accurately edge to edge. The present paper describes some spectrophotometers in which the comparison is effected by allowing the two beams to fall alternately on the eye in rapid succession. The best method of obtaining an intense beam of parallel rays, having each ray of equal brightness, is first discussed, as the production of such a beam is very necessary in all spectrophotometric measurements of light absorption. Next there are briefly described three new types of "flicker" spectrophotometer, the first of these depending on polarisation, the second on refraction, and the third on reflection. All three are quite successful: the choice of the best to use depends on the circumstances of the case. Finally, three general governing principles are laid down which would seem to apply equally to all types of flicker photometer. A. W.

1939. *Double Refraction of Optical Glass.* E. Zschimmer and H. Schulz. (Ann. d. Physik, 42. 2. pp. 845-896, Sept. 23, 1918.)—A description of the apparatus used in this research has previously been given [see Abstracts Nos. 888 and 1807 (1918)]. The research deals with the dependence of the double refraction of optical glass on its chemical composition and on its shape. The way in which strain depends on the temperatures of the cooling process is dealt with at length. It was found by extrapolation that a glass containing about 76 % PbO should have the property of exhibiting no double refraction, whatever the cooling process, for light of wave-length $\lambda 5461$. The PbO-content of a glass found by Pockels to show no double refraction for any deformation was 75.7 %. A. W.

1940. *Refraction of Gases at Different Temperatures and Pressures.* H. D. Ayres. (Phys. Rev. 2. Ser. 2. pp. 161-182, Sept., 1918.)—An interference method was used in the experiments, and the change ensuing in the optical path of light traversing twice the distance between two reflecting surfaces upon admitting a gas to the space between the surfaces, was determined. If k is the total shift of interference bands of wave-length λ , n the index of refraction of the gas, and d the distance between the surfaces, then $n - 1 = k\lambda/2d$. The gases dealt with were air, nitrogen, oxygen, hydrogen, and CO₂. Observations were made about 0° C. and at temperatures ranging down to that of liquid air. The results are tabulated and graphed. From the various curves it is seen that within the limits of accuracy of observations of experiments, the relation between the indices of refraction and the pressure is a linear one except for the case of CO₂ at 0° and for nitrogen at liquid-air temperature. In other words, the relation between the refractive indices and the density as

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computed by Boyle's law is a linear one. For the CO₂ at 0° C. and the nitrogen at liquid-air temperature the densities have been computed by means of van der Waals' equation. Using the value of the constants a and b obtained from the critical pressure and temperature of the respective gases, the relation between the resulting densities and refractive indices was found to be very accurately a straight line. A table is also given showing the variation of the refractive indices with the densities as obtained by the two methods, and also comparing the formula of Gladstone and Dale with the Lorentz-Lorenz formula. It may be noted that for nitrogen at 0° C. (excluding the two lowest pressures), computing the densities by Boyle's law and using the Gladstone and Dale expression, the values of the constant vary only about 0.2 %. A. W.

1941. *Gouy-Sommerfeld's Diffraction*. A. Kalaschnikow. (Jurn. Russk. Fizik.-Chimičesk. Obščestva, 44. 8. pp. 187-144, 1912.)—Demonstrates that by photographic means, diffraction at a greatly bent angle is easy to observe. The author's experimental results are in agreement with Sommerfeld's theory. I. P.

1942. *Passage of Waves through Fine Slits in Thin Opaque Screens*. Rayleigh. (Roy. Soc., Proc. Ser. A. 89. pp. 194-219, Aug. 27, 1913.)—In a former paper (Phil. Mag. 43. p. 259, 1897; Scientific Papers, vol. 4, p. 288) the author gave solutions applicable to the passage of light through narrow slits in infinitely thin perfectly opaque screens, for the two principal cases where the polarisation is either parallel or perpendicular to the length of the slit. It appeared that if the width ($2b$) of the slit is very small in comparison with the wave-length (λ), there is a much more free passage when the electric vector is perpendicular to the slit than when it is parallel to the slit, so that unpolarised light incident upon the screen will, after passage, appear polarised in the former manner. This conclusion is in accordance with the observations of Fizeau (in 1861) upon the very narrowest slits. Fizeau found, however, that somewhat wider slits (scratches upon silvered glass) gave the opposite polarisation; hence the present author wished to extend the calculation to slits of width comparable to λ . The subject has also a practical interest in connection with observations upon the Zeeman-effect.

Elliptic co-ordinates not offering a solution, though apparently appropriate to such a problem, the author again uses the approximate methods of the former paper. The result of the theory is that for very narrow slits the light with electric vector perpendicular to the slit is favoured, for slits of a certain critical width the two polarisations are equally treated, and finally, for wider slits the light with electric vector parallel to the slit is favoured. Curves for the two polarisations are given and one crosses the other at the critical width of slit. If the incident light were white and the width of the slit about one-third the wave-length of yellow-green, there could be distinctly marked opposite polarisations at the ends of the spectrum. This is in good agreement with the estimates of Fizeau. These calculations do not apply to thick screens as in a spectroscopic slit. E. H. B.

1943. *Double Mirage*. W. Hillers. (Abhandl. des Naturwiss. Vereines, Hamburg. Phys. Zeitschr. 14. pp. 718-719, and 719-728, Aug. 1, 1913. Abstract.)—Describes and reproduces photographs of a triple mirage effect obtained at a wall heated by the sun. One of the pictures is that of a boy

leaning against the wall at a distance of 162 m. from the camera, which was 16 cm. from the wall. The mirror image immediately adjoins the figure, and beyond it again is a direct image. The author works out a mathematical theory of the mirage on the lines of Vince, but without using elliptic integrals.

E. E. F.

1944. *Scattering of Light*. J. R. Milne. (Roy. Soc. Edinburgh, Proc. 88, pp. 264-281, 1912-1918.)—The present paper describes a number of experiments made in connection with Christiansen's experiment in which a beam of light is passed through a transparent insoluble powder immersed in a liquid, with the result that light of the particular colour for which the indices of powder and liquid are the same passes unaffected, while light of all other colours is scattered. In this paper only the simplest case of the above is dealt with, that, namely, in which a flat piece of glass, ground on one side, takes the place of the powder (the rugosities of the ground surface representing a single layer of grains), and air takes the place of the liquid. In such a case there is, of course, no colour of light for which the indices of solid and liquid are alike, and it was found that the colour of the light made very little difference to the results. But different ways of grinding the glass surface led to very different effects. Each specimen of glass employed was photomicrographed, and had its polar light-distribution measured by a photometer. Two methods of characterising the particular scattering power of a screen have been formally defined—the one connected with the "angle of max. total emission," and the other with the "equivalent cavity." The investigation will be continued on the above lines, also in the direction of ascertaining the effect of a number of plates, and in investigating the polarisation effects, which some rough preliminary experiments have shown to be marked.

A. W.

1945. *Pressure of Light by Use of Thin Foil*. G. D. West. (Phys. Soc., Proc. 25, pp. 824-880 ; Discussion, p. 880, Aug., 1918.)—The pressure of the radiation emitted by a carbon filament lamp at a distance of a few cm. is sufficient to cause a microscopically measurable deflection of the end of a suspended strip of gold or aluminium foil, and by this means the radiation-pressure can be calculated knowing the weight of the strip. The results agree to within about 10 per cent. with the energy density of radiation as measured by the initial rise of temperature of a copper plate exposed to the radiation.

The best results are obtained by working in an atmosphere of hydrogen, 1 cm. to 2 cm. pressure, but good results are obtained with hydrogen at atmospheric pressure. Air at 1 cm. to 2 cm. pressure also gives good results. The method involves no laborious adjustments, and the apparatus is not seriously affected by vibration.

E. H. B.

1946. *Absorption of Gases in Infra-red*. E[va]v. Bahr. (Deutsch. Phys. Gesell., Verh. 15. 16, pp. 710-780, Aug. 80, 1918.)—The infra-red absorption bands of gases are discontinuous at low pressures. But the discontinuities are generally less marked as the pressure increases, so that the bands, when max. absorption is reached, appear to be almost continuous. Raising the temperature of CO has the effect of separating the two maxima of its absorption band from one another, at the same time causing a broadening of the band. The experimental results obtained up to the present are compared with Bjerrum's theory of infra-red absorption spectra and with various consequences of the theory. The agreement is in general satisfactory.

A. W.

1947. *New Band Spectrum associated with Helium.* W. E. Curtis. (Roy. Soc., Proc. Ser. A. 89. pp. 146-149, Aug. 19, 1918.)—In Fowler's recent observations of the principal series of hydrogen lines in the spectra of helium tubes traces were frequently seen of a band spectrum whose origin was unknown. With suitable precautions it was found possible to obtain the spectrum quite brightly, and further investigation showed that it may be attributed to He. An account of the spectrum has been given by Goldstein [Abstract No. 1488 (1918)], and is in close agreement with that here given. Photographs are reproduced and wave-length tables given, the bands extending from $\lambda 6899$ to $\lambda 8118$.
A. W.

1948. *New Series of Lines in the Spark Spectrum of Magnesium.* A. Fowler. (Roy. Soc., Proc. Ser. A. 89. pp. 188-187, Aug. 19, 1918.)—A recent investigation suggested that the spectrum of hydrogen was unique in having two principal series of lines which are related to each other in the same manner as the sharp and diffuse series. In seeking for further examples of such series, analogy with hydrogen suggested spark spectra as the most promising sources. One of the most remarkable spark lines is the Mg line $\lambda 4481$, which ordinarily is not visible at all in the arc, but is by far the strongest line in the spark. Further, there is a series of single lines in the arc spectrum of Mg, first identified by Rydberg, which it seemed might possibly be analogous to the Balmer series of hydrogen lines. But there were only two recorded lines which could possibly be connected in series with $\lambda 4481$; namely, the lines given by Exner and Haschek at $8106\cdot5$ and $2659\cdot5$. Other associated ultra-violet lines, however, have now been photographed, and it results that the spark-lines form two series like those of hydrogen, $\lambda 4481$ being analogous to the first principal line of hydrogen $\lambda 4686$. The results are discussed.
A. W.

1949. *Band Spectrum attributed to Carbon Monosulphide.* L. C. Martin. (Roy. Soc., Proc. Ser. A. 89. pp. 127-182, Aug. 19, 1918.)—The experiments described in the present paper were made in connection with the investigation of sulphur spectra developed by the nitrogen afterglow, in continuation of previous observations by Strutt and Fowler [see Abstracts Nos. 1889 (1911), 596, 1119, 1897 (1912)]. A result of considerable interest is the detection of a series of ultra-violet bands which appear to be characteristic of a compound of sulphur and carbon. This band system extends from $\lambda 2486$ to $\lambda 2887$ approximately. It is, however, quite distinct from that developed, in the same region, by CS_2 in the afterglow. Further photographs showed that the two sets of bands had nothing whatever in common. Confirmation of Strutt's work on the chemical actions taking place between CS_2 and the active nitrogen was obtained. A green deposit of nitrogen sulphide formed in the experimental tube, and also a brown one of polymerised carbon monosulphide, the latter only in the presence of a stray discharge. The new bands were observed by using a hollow carbon, well charged with sulphur, as the upper (positive) pole of the arc. In these circumstances a steady flow of melted sulphur into the arc was maintained. Like the sulphur bands, the new bands are degraded towards the less refrangible side. Experiments with a sulphur vacuum tube showed that the bands are not given by the discharge through pure sulphur vapour; also that they are only developed to any extent when the carbon line $\lambda 2478$ is present. They have nothing whatever to do with the ordinary spectra of carbon or nitrogen. Wave-length tables are given of the bands and photographs are reproduced.
A. W.

1950. *Measurement of Intensity Distribution in Spectral Lines*. II. P. P. Koch. (Ann. d. Physik, 42. 1. pp. 1-29, Aug. 26, 1918.)—In a previous paper a photographic-photometric method was described by which the intensity distribution in spectral lines may be determined [Abstract No. 759 (1911)]. It appeared that the measurements of the intensity distribution depended to a certain extent on the apparatus employed and possibly on the source of light. The present paper deals with the question of eliminating the effect of the apparatus and the estimation of the true intensity distribution. [See also Abstract No. 1858 (1912).] A. W.

1951. *Reflection Spectra of Neodymium Compounds*. P. Joye. (Archives des Sciences, 86. pp. 41-58, July, and pp. 118-188, Aug., 1918.)—Photographs and measurements have been made of the reflection spectra of a number of neodymium compounds. These include the hydrate $\text{Nd}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$, and the two hydrates, $2\text{Nd}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ and $\text{Nd}_2\text{O}_3 \cdot \text{H}_2\text{O}$, the existence of which has been ascertained; the oxide, sulphide, sulphate, chloride, bromide, carbonate, oxalate, and nitrate. The influence on the spectra of the presence of a foreign substance, of the temperature, and of the method of preparation of the salts has been investigated in certain cases. In general, the spectra are characterised by groups of lines for values of λ between 4200 and 4500, 5080 and 5480, and 5700 and 6000. Comparison of the spectra for the various hydrates shows that loss of water displaces the spectrum towards the red end. On the other hand, the introduction of acid radicals causes displacement towards the violet. The results are given in detail in the original paper. T. H. P.

1952. *Wave-length Standards*. C. Fabry and H. Buisson. (Journ. de Physique, 8. Ser. 5. pp. 618-622, Aug., 1918.)—The exactitude of secondary international standards is first discussed. It is seen that many researches lead to the conclusion that the values given by interference methods are perfectly correct and identical with those found by means of a grating. The paper then deals in succession with (i) The progress of measurements of secondary standards. (ii) Variability of wave-lengths. (iii) Tertiary standards of wave-length. (iv) The utility of having more numerous secondary standards measured by interference methods. A brief summary cannot be given. A. W.

1953. *Critical Study of Spectral Series*. III. W. M. Hicks. (Roy. Soc., Phil. Trans. 218. pp. 828-420, Oct. 22, 1918. Roy. Soc., Proc. Ser. A. 89. pp. 125-127, Aug. 19, 1918. Abstract.)—A continuation of previous work [see Abstract No. 1864 (1912)]. The present paper deals with the atomic weight term and its import in the constitution of spectra. The wave numbers of the lines in a spectrum which form any of the recognised series can be calculated, as is well known, from an expression of the form $n = N/D_1^2 - N/D_m$, where $N = 109675$ and $D_m = m + \text{fraction}$, the fraction being in general a function of the integer m . The constant doublet or triplet separations of sharp (S) and diffuse (D) series are formed by the deduction of a quantity Δ , or Δ_1 , Δ_2 in the case of triplets, from D_1 , and it has long been known that these quantities are very roughly proportional to the squares of the atomic weights when elements in the same group are compared. It is shown that there is a definite quantity in connection with each element which is of fundamental importance in the building up of its spectrum. It is proportional to the square of the atomic weight: in fact, if w denote the atomic weight divided by 100, its value is $(90.4725 \pm 0.0018)w^2$. This quantity is of such universal VOL. XVI.—A.—1918.

application that it is useful to have a special name for it, and it has been called the *oun* (w). Its value is denoted by δ_1 , but δ is used for the multiple $4\delta_1$, as it is of very frequent occurrence. The evidence for its existence is based on the arc spectra of He, the elements of groups I and II, the Al sub-group and Sc of III, and the O, S, Se of VI of the periodic table—in other words, all those elements in which the series lines have been allocated. It is found :—(i) That the Δ which give the doublet and triplet separations are all multiples of their respective *ouns*. (ii) That the corresponding quantities, which give the satellite separations in the D series, are also multiples of the *oun*. (iii) That the F series show the satellites depending in a similar way on the *oun*. (iv) That, in a large number of cases, lines are related in such a way that the differences of their denominators are multiples of the *oun*, and that frequently in place of an expected line which is not observed another occurs related to it in this manner : it is said to be collaterally displaced. After reviewing the evidence for the existence of the *oun* the paper deals in succession with :—(a) *The Constitution of the D Series*.—After establishing the dependence of the satellite separations on the *oun* it is shown to be possible that the D series may not depend directly on a formula involving m , but that the D_m of different orders may be given by the successive addition, or subtraction, of various multiples of the *oun*. It is curious that where there are no satellites these differences are multiples of the Δ themselves. Evidence is also given to show that the decimal part of $D(2)$, i.e. for the first line, is a multiple of Δ , or Δ_3 for triplets, but that, in the case where satellites exist, the extreme satellite is to be taken. (b) *The Constitution of the F Series*.—The F series is one whose limit is the variable part in the formula for the D series corresponding to the first of the D lines ; in other words, it depends on the D series in the same way that the limits for the S and D series depend on the first line of the P series. For all elements, except the alkaline earths, the lines are far in the ultra-red, and it is only recently that waves of extreme wave-lengths have been measured by Paschen. It is probable that the VF for the first lines in each sub-group may be the same, and even possible that it may be the same in all, the earths excepted. In the earths there is a very large number of strong well-defined lines which are connected collaterally with one another, or with the lines of the series themselves, the displacements proceeding by multiples of Δ . These afford values of large multiples of Δ , and hence of δ ; and, in consequence, give very exact values for the latter. (c) The preceding results are then discussed with a view to obtaining a better approximation to the value of the *oun* as a function of w^2 , on the supposition that it is always proportional to it. A value is obtained (see above) which is probably correct to a few units in the fifth significant figure. With further knowledge it is probable that this degree of accuracy may be extended to the sixth, and even beyond. It is clear that with such a knowledge of this constant, and with more definite and certain knowledge of spectral relations enabling values of δ of the same degree of accuracy to be obtained, it will be possible to determine atomic weights with extreme accuracy : an accuracy much beyond that attainable by methods depending on weighing. The large atomic weight of Ag, combined with the fact that it may be regarded as the basis of other atomic weights, would point to it as the best single element from which to deduce the value of δ/w^2 . The value of its doublet separation can be determined with extreme accuracy, to one or two units in the sixth significant figure. But, unfortunately, the deduction of Δ from this is subject to an uncertainty which quite upsets that degree of accuracy. The most probable value is, however, very close to that obtained by the final discussion.

The uncertainty is due to a doubt as to the real relations of lines usually assigned to the S, D, and P series of Ag, and it is hoped to clear this up by a further consideration of the spectrum. It is then shown how the laws indicated in the foregoing discussion enable the doublet and the satellite differences for Au, and the limits of the series to be determined. The value of Δ for Se is considered in Appendix I. In Appendix II the wave-lengths of the lines of the D and F series treated of, together with short historical notes, are given.

A. W.

1954. *Absorption Spectrum of Water-vapour*. E[va] v. Bahr. (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 781-787, Aug. 80, 1918.)—Further measurements of the absorption bands of water-vapour observed by Paschen at 5.9 and 6.5 μ lead to the conclusion that they probably constitute a Bjerrum double band. It further appears that both parts of this band are made up of a great number of narrow bands. The rotation frequency of the molecule as calculated from these narrow bands is in good agreement with the values found by Rubens in the residual ray region.

A. W.

1955. *Additional Triplets and other Series Lines in the Spectrum of Magnesium*. A. Fowler and W. H. Reynolds. (Roy. Soc., Proc. Ser. A. 89. pp. 137-145, Aug. 19, 1918.)—Eight additional triplets have been measured in the spectrum of the magnesium arc *in vacuo*, six of which belong to the Diffuse and two to the Sharp series. For some of the previously known lines improved wave-lengths have also been obtained. Four additional members of the Rydberg series of single lines have also been photographed. Even a four-constant formula does not accurately represent this series. Four strong solar lines of previously unknown origin have been identified with lines of the Rydberg series, namely, 4167.44, 4057.67, 8986.90, 8988.55. A previously unrecorded line at 4854.58 may be united in a series with the known lines 5711.81 and 4730.21, having the same limit as the Rydberg series. This series is probably of the Sharp or second subordinate type.

A. W.

1956. *Constitution of Mercury Green Line*. F. F. S. Bryson and J. Logie. (Phil. Mag. 26. pp. 366-375, Aug., 1918.)—From the investigations here dealt with it appears that the discrepancies in the positions of the satellites of the Hg green line as determined by different observers are for the most part apparent, not real, and are dependent upon the difficulty of judging the centre of the main wide line. A comparison table and diagrams are given, showing the positions and relative intensities of the satellites as determined by different observers. The discrepancies in the relative brightnesses in the different cases appear not to be due to any variations of temperature or of vapour pressure, and as they cannot well be attributed to absorption they remain at present unexplained. Experiments were undertaken with a view to studying the change of pattern observed by Janicki and by Galitzin and Wilip. The tubes used were exhausted by a Fleuss pump, and were in open connection with a P_2O_5 drying tube. On heating the tube slightly the effect was soon obtained. The discharge in the tube became very brilliant and very broad and continuous, suggesting a breakdown of the insulating properties of the vacuum, while the appearance in the echelon exactly corresponded to Janicki's description of "five equidistant bands." The temperature at which the effect is obtained varies from 200° C. to 260° C. or more, depending apparently upon the degree of vacuum. The effect, however, cannot be due solely

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to temperature, for in the earlier experiments the temperatures attained by the arc varied from 180°C. to over 400°C. , and with this arc the effect could not be observed. The effect is more easily obtained with an imperfectly exhausted tube, though it could always be obtained with the highest vacua obtainable with the pump employed. The nature of the discharge seems to have some slight effect. When the hammer of the coil was working unsteadily the appearance would flicker in and out even at temperatures below 200°C. , while when the proper conditions had been attained it worked smoothly. Measurements from photographs of the effect and the general appearance of the tubes when the effect is in evidence indicate that the effect is due to absorption, and is caused primarily by foreign vapours in the tube either left behind in exhausting, or obtained from the Al electrodes or the P_2O_5 tube; temperature and discharge being secondary factors. A. W.

1957. *Emission of "Rest" Series Lines by Canal Rays.* J. Stark. (Ann. d. Physik, 42. 1. pp. 168-180, Aug. 26, 1918.)—From observations on the canal rays of various elements the author concludes that—(a) The "rest" series lines are produced by a canal-ray particle piercing the outer layers and at the same time ionising a motionless atom. (b) The ratio of the intensity of complex "rest" lines to simple "rest" lines increases with the velocity of the canal rays. (c) Helium canal rays are favourable to the production of simple "rest" lines in another element. (d) Probably when a heavy canal-ray particle strikes an Al-atom it imparts light-energy and motion to it. (e) Canal-ray particles of heavy elements allow He-atoms to go through them without altering their velocity appreciably. J. M.

1958. *Anomalous Zeeman-effect in the Satellites of Mercury Lines.* H. Nagaoka and T. Takamine. (Nature, 91. pp. 660-661, Aug. 28, 1918.)—Owing to the extreme complexity in the distribution of lines when the field strength is increased, there have been up to now no continuous observations indicating the position of satellites of mercury lines in different magnetic fields, though several workers have shown that the satellites of some Hg lines are separated in a regular manner in weak fields, and Gmelin has found a satellite of the yellow line having anomalous character. Measurements have been made by the authors of the present paper on the satellites of the violet line $\lambda 4047$ and the green line $\lambda 5461$, in fields ranging up to 80,000 gauss, and it has been found that the satellites show anomalous Zeeman-effect, either as regards intensity or the mode of separation, and in nearly all cases both combined. An echelon grating was employed, sometimes crossed with a Fabry-Perot air plate or a Lummer-Gehrcke plane-parallel plate to eliminate the false lines. From a large number of photographs of the transverse effects obtained in different fields, which were mostly uniform but sometimes heterogeneous, the positions of the satellites were plotted and traced into continuous curves, which are reproduced, different diagrams showing the components vibrating parallel and perpendicular to the field respectively. It is seen that for parallel components the separation is not generally proportional to the magnetic field. The satellites of $\lambda 4047$ are characterised by approaching the central principal line asymptotically, while in weak fields the change in wave-length is quite rapid. The satellite at $-60\text{ m.}\text{\AA.}$ U. from the principal line is remarkable in possessing a branch towards the positive side approximately a parabola with vertical axis, and one towards the negative side a similar curve with horizontal axis; hence the change wrought by the magnetic field is proportional to \sqrt{H} for the former branch and to H^2 for the latter. Other satellites have similar peculiarities, which are discussed.

The different branches into which the satellites are divided ultimately run parallel to the principal lines, whether the vibration takes place parallel or perpendicular to the direction of the field. It is in the transition from zero field to this final stage that the separation of the satellites takes place in a singularly anomalous manner, which is seldom met with in the separation of the principal lines. This fact will have an important bearing on the elucidation of the nature of the satellite, and probably may have an intimate connection with the recent experiments of Paschen and Back.

The investigation is being continued with satellites of the lines of other elements. A. W.

1959. *Reflection of Canal Rays.* J. Stark. (Ann. d. Physik, 42. 1. pp. 281-287, Aug. 26, 1918.)—A note on E. Wagner's communication [Abstract No. 1474 (1918)]. The author's own experimental methods are defended and some additional observations given. [See Abstract No. 1085 (1909).] J. M.

1960. *Lines of Aluminium, Argon and Mercury in Canal Rays due to Singly- and Multiply-charged Ions.* J. Stark, G. Wendt, H. Kirschbaum and R. Künzer. (Ann. d. Physik, 42. 2. pp. 241-302, Sept. 28, 1918.)—A continuation of previous work [see Abstracts Nos. 982 and 1288 (1918)]. The researches dealt with show (i) aluminium may in the canal rays have singly-doubly-, or trebly-charged positive atomions, with three corresponding velocity intervals. With a kathode-fall of less than about 8000 volts, the singly- and doubly-charged Al-ions exceed in number the trebly-charged ions in the canal-ray bundle behind the kathode; if the kathode-fall exceeds 8000 volts the trebly-charged ions are found in much greater numbers. The differently charged ions are the carriers for different line spectra. To the spectrum of the singly-charged Al-ions belongs the doublet $\lambda 3961\cdot7, 3944\cdot2$; to the spectrum of the doubly-charged ions the line $\lambda 4668\cdot5$; and to the trebly-charged ions belong the lines $\lambda 4529\cdot7, \lambda 4518\cdot0$ and $\lambda 4480\cdot0$. (ii) Similarly it is found that argon shows the existence of singly-, doubly-, and trebly-charged ions. The lines of the red Ar-spectrum have for carriers positive singly-charged Ar-atomions. The lines of the blue Ar-spectrum in the visible region have for the greater part positive doubly-charged atomions, for the lesser part positive trebly-charged atomions as carriers. In the emission of the displaced line in the Ar canal-ray Doppler-effect, whether the rays pass into Ar or into He, there exists a variable state of equilibrium between the three kinds of ions. Slow kathode rays give rise to the emission of a preponderance of singly-charged Ar-lines, while quickly-moving kathode rays give rise more to doubly- and trebly-charged lines. (iii) Mercury exhibits ions with as many as four atomic charges. The carriers of the Hg doublet $\lambda 2847, 2224$ are the positive singly-charged Hg-atomions; the carriers of the first and second subordinate series of triplets are the positive doubly-charged ions. The lines $\lambda 4916, 4889, 4847, 4109, 4078$, have the positive trebly-charged ions; the intense lines appearing in the negative glow $\lambda 4797, 4707, 4480, 4898$, have the positive quadruply-charged ions as carriers. The line $\lambda 2586\cdot7$, probably the first member of a series of simple lines, has probably the neutral Hg-atom as carrier. Hg-canal rays in H or He show, for a kathode-fall of less than 8000 volts, a preponderance of singly- and doubly-charged rays, and only a very small proportion of trebly-charged rays. With a kathode-fall of 15,000 volts and upwards, there appear, besides the singly- and doubly-charged rays, a considerable number of trebly- and also of

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quadruply-charged rays. Between the neutral Hg canal-rays, the singly-, doubly-, trebly-, and quadruply-charged rays, there exists, under the conditions giving rise to the emission of the displaced line, a variable state of equilibrium.

A. W.

1961. Frequency of X-rays. W. Seitz. (Phys. Zeitschr. 14. pp. 659-660, July 15, 1918.)—A criticism of Zemlén's evaluation of energy quantum of Röntgen rays [Abstract No. 1298 (1918)]. The efficiency of the conversion of kathode-ray into X-ray energy is much higher than 0.001, since most of the X-rays are soft, and are absorbed by the glass or by the antikathode itself, It is quite possible that the energy of the X-rays is consistent with the value assigned by the quanta theory.

E. E. F.

1962. Structure of X-radiation. W. F. D. Chambers and I. G. Rankin. (Nature, 91. p. 686, Aug. 21, 1918.)—Following up the work previously recorded [see Abstract No. 1291 (1918)] the authors have now obtained results which point to the conclusion that some part of these effects at least must be referred to the structure of the primary beam. In an early trial arranged to study the disposition of the spots from a thin lamina of mica, normal to the beam and covering a $\frac{1}{4}$ -in. aperture, the spots were not present, but instead the photographic plate, exposed at a distance of 50 cm., was entirely covered by dark parallel bands about $\frac{1}{4}$ cm. wide and normal to a sharply defined bright cross. In later experiments without mica, and using cast-iron and other screens, both with and without apertures, a system of crossed bands appeared. The same phenomena appeared even when no other obstacle than a thick sheet of plate glass was interposed.

E. H. B.

1963. Effect of Thermal Movements on the Interference Phenomena of Röntgen Rays. P. Debye. (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 678-689, Aug. 15, 1918.)—A mathematical inquiry as to the effects, if any, of the thermal movement on the phenomena in question, from which the author concludes as follows :—(1) The thermal movements have no influence on the sharpness of the interference maxima. (2) Their influence on the intensity hindered the discovery of radiation with a wave-length $< 10^{-9}$ cm. [See next Abstract.]

E. H. B.

1964. Röntgen-ray Interference. P. Debye. (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 788-752, Aug. 30, 1918.)—A mathematical discussion of the distribution of intensity in the interference bands from Röntgen rays. The interference bands of a regular crystalline grating are first treated with special regard to the thermal movements; the effect of temperature is afterwards inquired into. The low-temperature work on the specific heat of diamond and the quantum hypothesis are also referred to. [See preceding Abstract and No. 1158 (1918).]

E. H. B.

1965. Transmission of X-rays through Metals. H. B. Keene. (Nature, 91. p. 607, Aug. 14, 1918.)—A parallel narrow beam of X-rays was allowed to pass normally through three rolled metal sheets and fall on a photographic plate placed behind and parallel to the sheet. The patterns obtained were found to fall into two classes : (a) in which the central spot produced by the direct beam is surrounded by an irregular halo of smaller spots; and (b), in which the central spot is surrounded by faint extended patches forming a perfectly symmetrical pattern. The design varies with the metal. Class (a)

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markings are given by metal sheets which are either well aged or recently annealed, while the symmetrical patterns of class (b) are only obtained with newly-rolled sheets. The spots of the former are due to reflections from the microcrystals within the metal, while the symmetrical patterns of the latter are produced by the structure imparted to the metal in passing through the rolls. These star-like patterns are evidently analogous to those obtained when a beam of light passes through a crystal which appears streaky to the naked eye. By annealing a newly-rolled sheet the pattern changes from class (b) to class (a), and *vice versa*. E. M.

1966. *Range and Ionisation of the α -Particle in Simple Gases.* T. S. Taylor. (Phil. Mag. 26. pp. 402-410, Sept., 1918.)—The ranges were determined by observing the distance from the source at which scintillations were no longer produced. The results are as follows :—

	Range at 760 mm. and 0° C.		760 mm. and 15° C.		Ratio of Ranges.
	Polonium.	Radium C.	Polonium.	Radium C.	
Air	8.57 cm.	6.57 cm.	8.77 cm.	6.98 cm.	1.84
O ₂	8.25	5.94	8.48	6.26	1.88
H ₂	15.95	29.86	16.88	30.98	1.84
He	16.70	30.84	17.62	32.54	1.84

Experiments were also made on the rate at which the number of α -particles from RaC diminishes towards the end of the "range," the pressure of the gas being adjusted so that the range was the same in each case. The results show that for H₂ and He the beam of α -particles remains much more nearly homogeneous than for O₂ or air. This result would be expected from the theory of scattering. The Bragg ionisation curves were also obtained in the various gases, and it is shown that the He curve has the most pronounced "peak," and this peak occurs a little nearer to the end of the range. The theoretical curve $I = c/(r - x)^{1/2}$ (where r is the average range of the α -particles, x the distance from the source, and c a constant) is found to agree better for He and H₂ than for air. By integration of the ionisation curves it is shown that the ratio of the total ionisation in helium to that in either air or hydrogen is 1.05.

E. M.

1967. *Notes on β - and γ -Rays.* J. A. Gray. (Phil. Mag. 26. 540-544, Sept., 1918.)—The paper deals with some effects of scattering on absorption curves of β - and γ -rays, and also on the comparison of the intensities of γ -rays which differ in penetrating power. In many cases, when taking absorption curves, it is found that the ionisation produced by the rays can be approximately expressed by the relation $I = I_0 e^{-\mu x}$, where I represents the ionisation and x the thickness of the absorbing material. It might appear at first sight that rays which were such that their quality was unchanged when they passed through matter would give such an ionisation curve. The author shows from a consideration of Schmidt's theory of absorption of β -rays [Abstract No. 1881 (1907)] that this is not necessarily the case. E. M.

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HEAT.

1968. *Atomic Specific Heats between the Boiling-points of Liquid Nitrogen and Hydrogen. I. Mean Atomic Specific Heats at 50° Abs. of the Elements a Periodic Function of the Atomic Weights.* **J. Dewar.** (Roy. Soc., Proc. Ser. A. 89. pp. 158-169, Aug. 27, 1918.)—The specific heats of 58 elements have been determined between the temperatures of boiling nitrogen and boiling hydrogen. The substances were cut into pieces of uniform shape and cooled in a jacket containing liquid nitrogen; they were then allowed to drop into a calorimeter containing liquid hydrogen, and the volume of hydrogen gas evolved was measured. The corrections necessary to be applied in the calculation of the specific heat are detailed. It is shown that the specific heat is a periodic function of the atomic weight, and that the atomic heat curve has a similar form to the Lothar Meyer atomic volume curve. T. S. P.

1969. *Emissivity of Oxidised Metallic Surfaces.* **C. P. Randolph and M. J. Overholser.** (Phys. Rev. 2. Ser. 2. pp. 144-152, Aug., 1918.)—An experimental research reaching the following conclusions:—(1) The emissivity of an oxidised metallic surface depends on the depth of the surface oxidation. It is accordingly a function of (a) the temperature to which the surface has been heated, and (b) the time the surface has been maintained at that temperature. (2) The emissivities of certain surfaces were found as given in the table for oxidations at about 600° C. and maintained until the emissivities were constant.

Surfaces.	Temperatures.		
	900° C.	400° C.	600° C.
Silver	0·020	0·080	0·088
Oxidised zinc	—	0·110	—
Oxidised aluminium	0·118	0·158	0·192
Oxidised nickel	0·869	0·424	0·478
Oxidised copper	0·568	0·568	0·568
Oxidised brass	0·610	0·600	0·589
Oxidised lead	0·681	—	—
Oxidised cast-iron	0·648	0·710	0·777
Oxidised steel	0·790	0·788	0·787
Black body	1·000	1·000	1·000

E. H. B.

1970. *Thermal Effects produced by Heating and Cooling Palladium in Hydrogen.* **J. H. Andrew and A. Holt.** (Roy. Soc., Proc. Ser. A. 89. pp. 170-186, Aug. 27, 1918.)—The authors have plotted the cooling and heating curves of palladium of various kinds in vacuum and in hydrogen. It is shown that Pd is probably dimorphic, the stability of the two forms depending on the temperature. The rate of change of the one form into the other is VOL. XVI.—A.—1918.

extremely slow. The initial rapid occlusion of hydrogen is probably due to the presence of the amorphous form of Pd, and in the absence of such an amorphous film Pd may be quite passive with regard to the occlusion of gas in the cold. It is probable, however, that the passivity is apparent rather than real, and that if sufficient time were allowed for occlusion to take place a volume of gas equal to that occluded by active Pd would pass into solution. At temperatures above 100° a rapid occlusion of a small quantity of hydrogen occurs with both forms of Pd, a constant quantity of heat being developed. Both varieties of Pd cease to absorb hydrogen above a certain temperature, and above 150° they both have an equal affinity for the gas. T. S. P.

1971. *Porous Plug Method for Mechanical Equivalent of Heat.* J. R. Roebuck. (Phys. Rev. 2. Ser. 2. pp. 79-94, Aug., 1918.)—A method of measuring the mechanical equivalent of heat by observations of the change of pressure and temperature when water is forced through a porous plug is fully described. Ordinarily the method would be complicated by a temperature-change caused by the readjustment of internal kinetic and potential energies with change of volume, and an adiabatic free expansion experiment would be necessary to determine it. However, with water, experiments to be published later show that by suitably choosing the working temperature (8.59°C.) and the initial and final pressures (84 kg./cm.^2 and 1 kg./cm.^2) no change of temperature occurs in free adiabatic expansion, so that the only temperature-change in the porous plug experiment under these conditions arises from the external work done. The pressure change was read by a mercury-in-glass open tube manometer, and the temperature-rise, amounting to 0.76 deg. C. , by means of two high-resistance Pt thermometers. The mean value of the mechanical equivalent obtained, 4.2087 , agrees well with that obtained by Barnes, 4.2078 , for this temperature. F. J. H.

1972. *Temperature Radiation of CO_2 .* H. Schmidt. (Ann. d. Physik, 42. 2. pp. 415-459, Sept. 28, 1918.)—Taking special precautions to ensure an homogeneous temperature in the gas mass, the author finds that:—(1) CO_2 shows the emission and absorption bands already observed by Paschen, proving that the temperature radiation of gases may be discontinuous. (2) With constant pressure the absorption increases with the temperature, but more rapidly on that side of the band corresponding to the longer wave-lengths. (8) Very probably Kirschhoff's law holds for the radiation of an evenly-heated mass of CO_2 . J. M.

1973. *Effect of Pressure on the Absorption of Long-wave Radiation in Gases.* E[va] v. Bahr. (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 678-677, Aug. 15, 1918.)—In this research the relation of the pressure and absorption of waves from 100 to 850μ in HCl , SO_2 , and H_2S was investigated. The absorption curves show a form similar to those obtained earlier for shorter waves. For pressures above 200 mm. the increase of absorption with pressure is almost linear. But for smaller pressures the absorption curves fell down more steeply, especially in the case of SO_2 . [See Abstracts Nos. 1772 (1910) and 1480 (1911).] E. H. B.

1974. *Convection and Radiation of Heat.* I. Langmuir. (Amer. Electrochem. Soc., Trans. 28. pp. 299-380 ; Discussion, pp. 380-382, 1918.)—The paper is an extension of the author's earlier work [see Abstracts Nos. 887 and VOL. XVI.—A.—1918.

827B (1912)] to cover convection of heat from plane surfaces. The author first develops formulæ for the loss of heat by free convection for plane surfaces, horizontal cylinders, and spheres, on the assumption that such convection really consists in conduction through a film of gas of definite thickness. On this theory, if the value of the film thickness is known for a plane surface, it can readily be calculated for the others, and by the use of a formula given in a previous paper for the dependence of the conductivity of gases upon temperature, the quantity of heat lost by convection can be calculated for any temperature. Experiments are described in which the heat lost from plane surfaces at various temperatures is determined. This includes heat lost both by convection and radiation, but by using silver as the standard substance, and calculating the small amount of heat lost from it through radiation by means of Hagen and Rubens' formula combined with Wien's displacement law, the amount lost by convection from the various surfaces is determined. The value of the film thickness for a vertical plane surface calculated from this is independent of the temperature above 400°C. , and agrees very closely with that obtained from experiments with small wires; at low temperatures, however, a greater film thickness is required. The laws of Dulong and Petit and of Lorenz are shown to hold very satisfactorily even up to high temperatures, giving better results than the film theory for low temperatures, but they do not enable the effect of size and shape to be taken into account. From horizontal surfaces the convection from the upper surface is 10 % greater, and from the lower 50 % smaller, than from the vertical surface. By applying the values for the convection loss from silver to the results with other substances, the amounts of heat radiated, and consequently the emissivities, are determined. Curves are given which show the variation with temperature of the total amount of heat lost from the various surfaces. The film theory is found not to apply to convection forced by air currents, but Russell's formula [see Abstract No. 108 (1911)] agrees well with experimental data.

F. J. H.

1975. *Monatomic Gases and the Quanta Theory.* W. H. Keesom. (Phys. Zeitschr. 14. pp. 665-670, Aug. 1, 1918.)—An attempt to apply Debye's method of calculating specific heats to an ideal monatomic gas instead of a solid. The attempt in this direction made by Tetrode [Abstract No. 1018 (1918)] only leads to results in agreement with the equation of condition of helium if the "temperature energy" per frequency is increased by a "zero energy" having the amount $\frac{1}{2} h\nu$, as already attributed by Einstein and Stern to the rotation of H_2 molecules. Helium has at normal densities a zero-point pressure of $\frac{1}{2}$ mm. The author assumes that the spectrum of a gas can be indicated by Debye's method for solids. He shows that the pressure is always greater than the equipartition pressure $p = RT/v$, especially at low temperatures. Nernst's heat theorem applies also to an ideal gas. The author deals with pressure and specific heat on these lines.

E. E. F.

1976. *Free Electrons in Metals.* W. H. Keesom. (Phys. Zeitschr. 14. pp. 670-675, Aug. 1, 1918.)—Applies the results of the preceding paper to an "ideal gas" consisting of electrons in the interior of a metal. At low temperatures the number of free electrons per unit volume approaches a constant finite value, and so does the mean speed, thus agreeing with W. Wien's theory of electric conduction [Abstract No. 658 (1918)]. For high temperatures the theories of Riecke, Drude, and Lorentz are approached. Two difficulties hitherto confronting the equipartition theory are eliminated, one

being the high conductivity found by Onnes at the lowest temperatures, and the other difficulty that offered by the small contribution of free electrons to specific heat, especially in the theory of the Thomson-effect. It becomes possible to assign definite density values to the electrons at a given temperature. The author deals with thermoelectric force and the Thomson-effect along these lines. E. E. F.

1977. Vapour Pressure and Entropy of Monatomic Substances. O. Stern. (Phys. Zeitschr. 14. pp. 629-682, July 15, 1918.)—The absolute value of the vapour pressure of a solid substance can be calculated by the quanta theory, which gives the entropy constants of the gas and the solid. A second method is by the interpretation of vaporisation by molecular theory. The author calculates the vapour-pressure formula for a monatomic solid possessing the Dulong-Petit specific heat (1) thermodynamically, with the aid of the quanta theory; (2) kinetically, with the aid of Boltzmann's "c-theorem." The vapour is taken to be an ideal gas, the solid as consisting of identical monochromatic resonators. Both methods give the same formula for the vapour pressure at high temperatures, viz.—

$$p = (2\pi)^{3/2} \frac{m^{3/2} \nu^3}{h^3} \frac{1}{T^4} e^{-\lambda_0/RT},$$

where $h = R/N$ and ν is the frequency of the resonators.

E. E. F.

1978. Partition of Velocities. E. Gehrcke. (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 669-672, Aug. 15, 1918.)—Remarks upon the partition of energy between gas molecules and electrons. Two graphs are plotted on the same diagram; one is $y = x^2 \cdot e^{-58x}$, and represents Maxwell's law; the other is $y = x^4 \cdot (e^{ax} - 1)^{-1}$, in which the a is unity. This is practically coincident with the first for small values of x , but for larger values (*i.e.* beyond the maximum y) this second curve falls more rapidly and departs considerably from the first. From this second form, and other considerations, the author reaches the well-known radiation formula $\phi(\lambda, \theta) = c_1/[\lambda^5 (e^{c_2/\lambda\theta} - 1)]$.

E. H. B.

1979. Statistical Mechanics and Probability of a Complexion. P. Hertz. (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 177-196, 1918.)—Mathematical treatment of this thermodynamical problem. E. H. B.

1980. Mechanism of Black Radiation. A. Korn. (Phys. Zeitschr. 14. pp. 682-688, July 15, 1918.)—Introduces the Maxwellian distribution of velocities into the conception of pulsating electric charges, and obtains a time function of their velocity which, like Planck's radiation formula, yields Wien's law for high frequencies and Rayleigh's for low frequencies.

E. E. F.

1981. Deviations from the Law of Partition of Energy. J. D. van der Waals. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 84-90, Sept. 8, 1918.)—A probable formula, consistent with what is known of kinetic energy, is suggested for a special case of deviation from the partition law for a distribution in configuration, such as the author called attention to in his preceding paper [Abstract No. 1696 (1918)]. This formula is employed to derive one for the dissociation equilibrium of diatomic gases which shows a certain analogy with the results of Nernst's Wärmetheorie. G. W. DE T.

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ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

1982. *Electric Effect of a Magnetic Insulator Rotating in a Magnetic Field.* M[arjorie] Wilson and H. A. Wilson. (Roy. Soc., Proc. Ser. A. 89. pp. 99-106, Aug. 19, 1918.)—In a previous paper H. A. Wilson showed that when an insulator of dielectric constant K rotates in a magnetic field there is an e.m.f. induced in it equal to that in a conductor multiplied by $1 - K^{-1}$. The object of the present work was to measure the induced e.m.f. in a magnetic insulator rotating in a magnetic field parallel to the axis of rotation. According to the theory based on the "principle of relativity" this induced e.m.f. should be equal to that in a conductor multiplied by $1 - (\mu K)^{-1}$, where μ is the magnetic permeability of the insulator, whereas in the theory of H. A. Lorentz and Larmor, the appropriate multiplier appears to be $1 - K^{-1}$, as for a non-magnetic insulator. No insulator is known for which μ differs appreciably from unity, so that it was necessary to construct a model of a magnetic insulator. It consisted of wax in which a large number of small steel spheres were embedded. The spheres were $\frac{1}{8}$ in. in diam. and each one was coated thinly with sealing-wax. The coated spheres were packed tightly and melted paraffin wax poured in to make a solid mass. The value of K for this insulator was 6 and that of μ was 8. Thus $1 - (\mu K)^{-1} = 0.944$, and $1 - K^{-1} = 0.88$. The ratio of the observed effect to that in a conductor was 0.96. Hence these experiments confirm the theory of relativity, but do not necessarily conflict with the fundamental assumption of the theory of H. A. Lorentz and Larmor, as possibly their value would not apply to the composite medium employed here.

E. H. B.

1983. *Electron Theory of Thermo-electricity.* J. M'Whan. (Roy. Soc. Edinburgh, Proc. 28. pp. 169-176, 1912-1918.)—The preliminary argument of this paper may be summarised thus :—Incandescent bodies have been found, speaking generally, to emit negative electrons with great readiness, the saturation current of emission of electrons being found to be a definite function of the absolute temperature. H. A. Wilson regarded this emission of electrons as an evaporation of negative electricity through the surface of the hot body, determined by the nature and temperature of the body and by a definite "vapour pressure of electrons." This view is then worked out mathematically, and it is hoped to test the results experimentally. [See Abstract No. 1689 (1910).]

E. H. B.

DISCHARGE AND OSCILLATIONS.

1984. *Current Curves in Ionised Air.* E. Wertheimer. (Phys. Zeitschr 14. pp. 711-717, Aug. 1, 1918.)—Since current curves in air ionised by X-rays have been obtained by Seemann [Abstract No. 1565 (1912)] and those with α -rays are well known, the author has studied the current- and potential-curves in the case of ionisation by β - and γ -rays, avoiding secondary radiation as much as possible. He used a Kleiner electrometer [Abstract No. 1201 (1918)] giving 4692 mm. per volt, and a Bronson resistance of VOL. XVI.—A.—1918.

2.06×10^{11} ohms. The curves obtained are compared with the approximate formula of Greinacher and the accurate formulæ of Mie. The recombination coefficient is seven times greater than that assumed by Mie. This is attributed to the circumstance of the ionisation not being homogeneous (ions equally distributed in the chamber) as assumed by Mie. E. E. F.

1985. *Quantum Theory and Emission of Electricity from Hot Bodies.* W. Wilson. (Phys. Soc., Proc. 25. pp. 881-885; Discussion, p. 885, Aug., 1918.)—For the purposes of this paper Planck's formula is put in the form—

$$I\nu d\nu = C\nu^3 \frac{d\nu}{e^{h\nu/kT} - 1}$$

in which $I\nu d\nu$ denotes the energy within the frequency limits ν and $\nu + d\nu$ emitted per sec. by the "resonators" of the radiating material, T is the absolute temperature, C a suitable constant, and h and k the universal constants of nature which are taken as—

$$h = 6.415 \times 10^{-27} \text{ erg-sec.}$$

$$k = 1.84 \times 10^{-16} \text{ erg per degree.}$$

The latter constant is identical with the absolute gas constant reckoned for one molecule. It is possible, therefore, to deduce from measurements on black radiation the number of molecules of an ideal gas per cm.³ under standard conditions of pressure and temperature. Planck thus finds $N = 2.77 \times 10^{19}$. A further consequence of this theory and the results of electrolysis makes $e = 4.87 \times 10^{-10}$ e.s. unit. Following up this theory, and applying it to the case in question, the author obtains a formula connecting the thermionic current and the temperature of the emitting body. This closely resembles Richardson's formula and agrees slightly better with experimental results.

J. W. Nicholson thought that Planck's constant h was in some way an electron constant, and that the emission of energy was discontinuous because the emission of electrons was discontinuous. E. H. B.

1986. *Influence of Oxygen on the Selective Photo-effect of Potassium.* R. Pohl and P. Pringsheim. (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 625-636, Aug. 15, 1918.)—When pure potassium is brought in contact with oxygen at low pressures a dark-coloured surface layer forms, which appears to be of a colloidal nature consisting of particles of potassium suspended in a potassium-oxygen compound. It is extraordinarily sensitive photoelectrically to visible light; so that in the violet part of the spectrum an output of 240×10^{-4} coulomb per incident light-calorie can be observed. The maximum of this selective power of excitation is, compared with that of pure potassium, displaced about 7 % towards the shorter wave-length, viz., from $4486 \mu\mu$ about to $4405 \mu\mu$ about. At the same time there is produced in the ultra-violet, below $4280 \mu\mu$, a very strong rise of electronic emission in the direction of higher frequency, which probably corresponds to the normal photo-effect of a potassium oxide. A. E. G.

1987. *The Long-wave Limit of Normal Photo-effects.* R. Pohl and P. Pringsheim. (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 687-644, Aug. 15, 1918.)—The experimental results which have been obtained appear to prove that the long-wave limit of the photo-effect serves as a measure of the combination of the electron to a molecule acted upon by light. Still, opposed to the experimental results which have been obtained, in accepting this limit

as a quantitative measure of the work of separation of the electrons, there is the difficulty that the long-wave limit of the normal effects with many metals and alloys is subjected to a fluctuation of an octave or more, at the same time it is not possible to state what influence on and in the extremely thin surface boundaries of the metals, in which the absorption of light occurs, is responsible for the displacement of the long-wave limit. A. E. G.

1988. *Observation of Variations of Photoelectric Effect.* P. Pringsheim. (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 705-709, Aug. 30, 1918.)—In this paper a method is described by which variations of the photoelectric effect may be followed. The method makes use of a sensitive negatively charged point projecting axially inside a small copper cylinder, and is thus similar to Geiger's method for counting β -rays [Abstract No. 1878 (1918)]. A small hole in the side of the cylinder admits the light, which falls on the charged wire. In pure nitrogen, with a positively-charged point, the momentary charges appear on illuminating the electrode, so that with this arrangement the variation of the photoelectric effect for solid or fluid materials can be observed. [See also Abstract No. 2091 (1907).] A. W.

1989. *Anomalous Anode-falls and the Formation of Anode Rays.* O. Reichenheim. (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 658-668, Aug. 15, 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—Extraordinarily high anode-falls have hitherto been observed with strongly electro-negative gases and vapours by the author and others [see Abstract No. 1089 (1909)]. Raisch [Abstract No. 875 (1912)] attributed the abnormality in the case of chlorine to the fact that the anode is acted upon chemically by the gas, the high fall of potential being caused by the badly conducting layer thus formed on the anode surface. The author, after pointing out that this explanation is not in keeping with facts concerning the production of anode rays, describes experiments which show that the fall of potential takes place in the gas itself, and that the abnormal fall is due simply to the decrease in the size of the effective anode caused by the chemical action. Anomalous anode-falls up to 100 times the normal could be obtained in iodine, bromine, air, hydrogen, and helium by decreasing the size of the anode sufficiently. These anomalous anode-falls obey laws similar to those obeyed by anomalous kathode-falls, viz., increasing with decreasing anode-surface, with reduction of pressure, and with increasing current. By means of the large anode-falls produced in the manner described or by means of the high potential-fall in the neighbourhood of a very fine constriction in the discharge, anode rays are produced even in electropositive gases such as hydrogen and helium, which further shows that the anomalous anode-falls are falls of potential in the gas and not in an insulating or double layer on the anode. F. J. H.

1990. *Electric Currents through Air Films.* A. Anderson. (Phil. Mag. 26. pp. 851-858, Aug., 1918.)—Two brass bars with carefully worked plane ends of area 1.15 cm.² are mounted firmly on paraffin blocks stuck on a copper plate, so as to include between them a rectangular film of air of a uniform thickness of about 0.002 cm. Currents between two such bars are produced by very small p.d.'s., and increase with the applied voltage, for pressures up to about 80 volts, approximately according to Ohm's law, after which the increase in current is much more rapid than the increase of voltage. Everything points to the formation of ions in the surfaces of the

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film of air in contact with the ends of the bars, which ions become available as carriers when the opposing surfaces are close enough. These ions can be removed by removing the air, and when the air is introduced again they are again formed, but not instantaneously. Their formation requires time. It is probable that such layers of ions exist at the surfaces of all bodies in contact with the atmosphere, and that they play a prominent part in coherer action and in all cases of the discharge of bodies by contact. A. E. G.

1901. *Hysteresis in Vacuum Tubes*. K. Fischer. (Phys. Zeitschr. 14. pp. 708-710, Aug. 1, 1913.)—When in a vacuum tube the current is gradually increased and then allowed to fall from the highest attainable value, a hysteresis loop is obtained. The returning branch is below the original characteristic in the case of higher pressures, and above it in the case of lower pressures. The former the author calls positive, the latter negative, hysteresis. Between those two pressures there is a region of no hysteresis. The hysteresis does not produce any permanent changes in the tubes, and for small currents the ascending and descending branches coincide. The hysteresis is practically independent of the purity of the gas, but greatly affects the appearance of the discharge, complete stratification only being observed in the case of negative hysteresis. The two branches of the double characteristic give different positive columns, with different lengths and numbers of strata. These hysteresis phenomena are probably connected with those observed in the arc discharge. E. E. F.

1902. *Observations of the Afterglow*. B. Thieme. (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 794-796, Aug. 80, 1913.)—The author in a preliminary communication describes briefly several new observations bearing on the afterglow produced in the gas of a low-voltage carbon-filament lamp after a discharge has been made to pass, by placing it in an alternating field of high frequency (Tesla field). He concludes that the afterglow is a periodic discharge occurring about 80 or 40 times a second, the period becoming smaller the longer the duration of the effect. Experiments on the discharge which occurs when the bulb of the lamp is electrified by friction are also described, the conclusion again being that the discharge is periodic. Further experiments are being made which will be fully described in a later communication. F. J. H.

1903. *Effect of a Low-potential Current upon Photographic Plates*. H. V. Gill. (Roy. Dublin Soc., Proc. 14. 5. pp. 74-78, July, 1913.)—A considerable amount of experimental work has been done concerning the nature of the electric discharge, by causing sparks to pass over the sensitive surface of dry photographic plates. The question naturally arises whether the record obtained on development of the plate is to be attributed to some electric reaction, or simply to the luminosity of the discharge. For this reason experiments are now undertaken with currents which certainly are not luminous to determine the part played by the purely electric elements of the discharge. The plates are soaked in clean water for 5 or 10 minutes, and are then pressed for a moment between sheets of clean blotting-paper to remove any superfluous water from front and back. The electrodes are coins or other flat pieces of metal connected by wires to the terminals of a battery of storage cells giving a p.d. of 400 volts. These coins are placed on the gelatine surface of the plate and kept in position by wooden clips; the "exposure" occupies about 10 minutes. In general it is found that the effect produced at the

kathode does not depend on the nature of the metal employed, and is less marked than that at the anode, but is present even when no blackening is produced at the anode. The kathode effect consists of a number of ray-like projections stretching out on the side facing the anode, being much less or altogether absent, on the more distant side. This is accompanied by a slight blistering of the moist gelatine surface, as if gas has been liberated. The effect at the anode is characteristic of the metal used as electrode, and appears to consist of two reactions, both of which are not always observed. One of these reactions appears to be common to all metals, and does not of itself result in a blackening of the plate on development. It may be observed in the red light of the dark room during process of exposure. It consists in a slight swelling of the gelatine surface of the plate, which swelling is seen to extend more or less uniformly around the anode. The other effect is apparently connected closely with that just referred to, but is not always present. This second reaction results in a blackening of the plate on development. The rate at which these effects spread out gradually falls off, and at the same time the current decreases. The falling-off of the current seems to be due to some polarisation effect, and explains the fact that an exposure of 10 minutes produces almost as marked an effect as one of an hour's duration. Sometimes there is a metallic deposit at point of contact of the anode. The following metals are tested as anode, and the peculiarities observed are given : Cu, Ag, Fe, Ni, Pt, Bi, C, Co, Cd, Zn, and a gold coin. Photographs of results are also included. As a whole the results of the experiments suggest the possibility of their being connected with the reactions studied by Lodge, Whetham, and others in gelatinous and other solutions, and are no doubt due to some reaction of metallic ions on the sensitive salts contained in the coating of the photographic plates.

A. E. G.

1904. Effect of Change of Diameter on the Potential Difference of a Discharge Tube containing Neon. G. Claude. (*Comptes Rendus*, 157. pp. 482-485, Sept. 1, 1918.)—Alternating currents were sent in turn through a number of discharge tubes 5 m. in length and varying in diam. from 5.2 mm. to 45 mm. The pressure, 2 mm. of mercury, was the same for all, as was also the current density, with the exception of that in the smaller tubes in which larger current densities were required to maintain the discharge. With small tubes, however, the p.d. varies but little with the current density. The values of the p.d., diminished by 350 volts for the fall at the electrodes, when plotted against the diam. give a rectangular hyperbola, the equation to which is $y = 4800/x$, where y refers to the p.d. per m. of tube and x to the diam. in mm. This result is corroborated by the known fact that in the striated discharge the distance between successive striæ never exceeds the diam. of the tube. An additional experiment at 1.8 mm. pressure confirmed the above result.

F. J. H.

1905. Action of a Magnetic Field upon the Electric Discharge through Gases. L. T. More and S. J. Mauchly. (*Phil. Mag.* 26. pp. 252-267, Aug., 1918.)—The authors, after reviewing Righi's work on the action of a magnetic field upon the discharge in a vacuum tube [see Abstract No. 561 (1912)] bring forward several points which are difficult to explain upon the neutral doublet theory advanced by Righi. As the result of experiments with a new modification of Righi's apparatus in which a lime kathode is used for the discharge, they are forced to abandon his theory and offer a fairly accurate and much simpler explanation, viz., that the effect of the magnetic field is just that of

displacing the discharge from the kathode and of magnifying it so that its various parts seem to be changed. Under certain conditions of pressure, potential, and temperature of the lime kathode, all the phenomena observed by Righi with the magnetic field can be reproduced in a large tube arranged behind the lime kathode without the magnetic field at all, simply by earthing the kathode and a gauze screen surrounding the tube. The main actions of the magnetic field are (1) to reduce greatly the potential drop at the kathode, (2) to concentrate the discharge to one or more bright streams from the kathode, and (8) to force the electrons to move away from the kathode in helical paths. These features, with the exception of the fact that the electrons move in straight instead of helical paths, are characteristic of the lime kathode discharge. The conical shape of the luminous column called by Righi the "magnetic rays" cannot be explained on the doublet theory, but receives a ready explanation in the fact that the electrons are moving in coincident magnetic and electric fields, the latter being more concentrated along the axis of the tube and the former diminishing more rapidly than the latter. The intermittency of the induced discharge is found to be a feature of that produced with the lime kathode as well as of that produced by a magnetic field, which thus disproves Righi's statements that a magnetic field is necessary for a periodic discharge, and that the doublet theory alone will explain it. The periodicity can be regulated by an adjustment of the conditions and seems to be due to the accumulation of electrons at the kathode until a critical point is reached, when the discharge ensues, ceasing immediately after, however, until the requisite number of electrons have again accumulated. A virtual anode in the "induced column," the existence of which is emphasised by Righi in support of his theory, is also obtained without a magnetic field. A complete Crookes' tube discharge is found to exist on the side of the kathode remote from the anode and a virtual anode is produced whenever the positive column of this discharge is forced into the large tube. In order to effect this Righi had to use a magnetic field, but the authors find that it can be done by earthing the lime kathode and the gauze screen. Under these conditions a current of electricity is found to be passing from the earth into the interior of the tube through the glass walls. A number of diagrams illustrating the various types of discharge obtainable are included in the paper.

F. J. H.

1906. *The Deposit upon the Poles of Metallic Arcs.* W. G. Duffield. (Phil. Mag. 26. pp. 388-345, Aug., 1918.)—The paper describes some remarkable growths of organic appearance which the author has observed upon the poles of the electric arc when viewed under the microscope through coloured glass. The observations were made chiefly with horizontal poles of copper, iron, and silver, and various combinations of these with each other and with carbon. The outstanding features of the growths are (1) their easier formation on the kathode than on the anode, (2) their formation upon a third electrode placed just above the arc, if its potential be sufficiently high and especially if it be negative, the latter being the only case in which the phenomenon occurs with silver, (8) their easier formation on a pointed electrode, (4) their derivation from the material of either the anode or the kathode but chiefly from the latter, (5) their organic form which is different for different metals, (6) the rapidity of their development as they approach the anode or when an outburst of vapour occurs, (7) the increasing difficulty of their formation with increasing atomic weight of the metal. Three lines of argument are developed to account for the phenomena and to explain the predominating

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influence of the kathode. (a) The gases rising from the metallic arc are ionised, the ions having vapour condensed upon them and chiefly upon the negative ions. The positive ions which thus have a larger mobility than the negative ions, are carried on to the kathode by the field which is insufficient to sweep out the negative ions. With silver, even the positive ions on account of the high atomic weight cannot be removed except by increasing the field considerably by the aid of a third electrode negatively charged. The negative ions of copper and iron can be removed by a third electrode raised to a high positive potential. (b) The kathode discharges electrons both on account of its high temperature and by the action of ultra-violet light, which electrons form nuclei for the condensation of the rising and rapidly cooling vapour. Particles near the kathode, although negatively charged, will be attracted by it and held by cohesive forces. (c) The ultra-violet light acting upon the particles of vapour above the arc promotes the emission of electrons and leaves them positively charged. They will thus migrate towards the kathode. The branch-like character of the formations is attributed to the action of points in promoting growth by reason of the larger field in their neighbourhood, which field is also responsible for the rapidity of the growths there. The difference in the nature of the growths for different metals is thought to be due largely to the difference of the flexibility of the filaments formed. The fact that the material of the growths is derived chiefly from the kathode indicates that the anode of the arc is not the only source of positive ions. These may be generated by the collisions of the electrons ejected from the kathode with particles of vapour derived from the same. A number of photographs illustrating the phenomena are appended. F. J. H.

1997. *Energy and Resistance of Sparks caused by Closing and Breaking Electric Circuits.* O. E. Günther. (Ann. d. Physik, 42. 1. pp. 94-182, Aug. 26, 1918. Abbreviated Dissertation, Leipzig.)—The heat generated by sparks due to making and interrupting an electric current is determined by an air-thermometer. The current circuit is closed and broken by means of a special contact which is carefully described. The p.d. was varied from 4 to 100 volts and the current from 0.2 to 1 amp. When a capacity is connected in parallel with the contact, the energy of the spark on *closing* the circuit agrees with that to be expected from theory and the resistance of the spark would appear to be a constant. With no capacity parallel to the contact the resistance of the spark made by *interrupting* the current appears as a function of the speed of interruption. This is shown by oscillograms which give results agreeing with those of the air-thermometer. When no capacity is parallel to the contact the spark on interruption is of the nature of an *arc*. A condenser placed parallel to the arc suppresses the *arc*, and a *spark* discharge takes its place. The larger the capacity the smaller the spark on breaking the circuit and the larger the spark on closing it. The curve connecting the capacity with total spark-energy on both making and interrupting shows a minimum energy for a particular capacity. A formula for the calculation of this capacity is given. An oscillogram shows the increase of spark-resistance with oxidation of the place of contact. T. P. B.

1998. *Current in Tuned Secondary Condenser Circuit assuming that the Oscillation in the Primary Circuit falls off Linearly.* E. Taege. (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 753-772, Aug. 30, 1918.)—A mathematical paper which deals with the form of the oscillation in the secondary of two coupled condenser circuits, the oscillation in the primary circuit being

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assumed to fall off linearly: the condenser circuits are supposed to be in resonance. The investigation is also extended to the case when the oscillation in the primary circuit is suddenly interrupted by the quenching of the spark. T. P. B.

1999. *Electromagnetic Waves and the Mode of their Propagation*. G. W. O. Howe. (Electrician, 71. pp. 965-969, Sept. 19, 1918. Paper read before the British Association, at Birmingham. Elect. Rev. 78. pp. 486-489, Sept. 26, 1918. Abstract.)—The paper gives a simple method of making clear the mode of propagation of electrical energy. If power be transmitted by two wide strips of thin copper placed face to face and close together, the magnetic and electric fields will be approximately uniform throughout the space between the strips in any plane normal to the direction of transmission. Such a transmission line therefore proves an excellent method of approaching such conceptions as are involved in Poynting's theorem and electromagnetic wave phenomena. After a consideration of the continuous-current case, the paper deals with transmission of energy by alternating current and so ultimately with wireless telegraphy waves. In this last case the strips become discs. The electric and magnetic fields in the neighbourhood of the lower disc are identical in their nature with those near the earth but the variation with the distance from the generator is different. The want of agreement may be removed by making the height of the upper disc vary directly as the distance from the centre. The inductance and capacity per radial cm. of this transmission line are constant as is the case with the strips considered above. If this arrangement of inverted cone and lower disc is to give a correct representation of the actual radio-telegraphic waves, it is shown that the angle between the conical surface and the disc must be 85° . Stress is laid upon the fact that the transmission of energy depends upon the simultaneous existence of the electric and magnetic fields. T. P. B.

2000. *Absorption of Electric Waves in Iron*. K. F. Lindman. (Ann. d. Physik, 42. 1. pp. 80-44, Aug. 26, 1918.)—The wave-length employed is 26 cm. The author builds up systems of circular resonators which are in resonance with this wave-length. The resonators are arranged in vertical columns about 10 cm. apart. He finds the energy transmitted through and reflected by these systems (1) when the resonators are made of copper, (2) when they are made of iron. The copper resonators both transmit and reflect the waves better than the iron resonators; the smaller transmission in the case of iron is, therefore, not due to better reflection. A reduction of the cross-section of the iron resonators by one-half does not affect the result in either case, so that the greater absorption in the iron resonators cannot arise so much from the resistance as from the magnetic property of iron. Reflection from an iron *sheet* is practically the same as from a copper *sheet*, but there is still a difference of 2 % in favour of the latter. Klemenčič's value for the permeability of iron for Hertz waves, viz. 100, would seem to be about correct. The author has not been able to detect the Kerr-effect with Hertz waves of 16 cm. wave-length. T. P. B.

2001. *Short-wave Electric Transmitters*. G. Mie. (Phys. Zeitschr. 14. pp. 728-725, Aug. 1, 1918.)—Remarks on the paper of Leimbach [Abstract No. 1486 (1918)]. The author maintains that Leimbach did not obtain any quenched spark with rod oscillators at all, but only the Hertzian oscillating spark. Even with spark-lengths of 0.02 mm. the sparks were probably

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oscillatory. No quenching takes place in air, because the air retains its conductivity too long. Good quenched sparks are obtainable in coal gas, but not in gases in which the spark cannot liberate soot. E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2002. *Light Emission and Electric Conductivity*. J. Koenigsberger. (Phys. Zeitschr. 14. pp. 648-646, July 15, 1918.)—Experiments on conducting filaments made out of compressed Auer substance provided with Pt electrodes show that there is no polarisation, and that therefore the conductivity is of a metallic nature. It can be shown generally, on electronic principles, that metallic conductivity, as distinguished from electrolytic, is responsible for luminous emissivity at high temperatures. Substances with a metallic conductivity begin to be transparent towards the end of the visible spectrum on the red side, and are generally transparent in the ultra-violet unless there is selective absorption. For the time of describing the mean free path of the electron is greater than the period of the incident light, the light-energy stored by the electron is not damped and transmuted, but restored to the ether. This may produce a displacement of phase, but no absorption. What may be briefly called the "collision interval" (Stosszeit) amounts to about 1.4×10^{-14} sec. (Reinganum, J. J. Thomson). E. E. F.

2003. *Electrical Conductivity of Sulphur*. M. Pigulewsky. (Jurn. Russk. Fizik.-Chimičesk Obščestva, 44. 2. pp. 105-122, 1912.)—Not being satisfied with the experiments made and conclusions arrived at by previous workers, including Wigand [1909], in explaining the change in conductivity of sulphur at higher temperatures, the author states the precautions necessary in making observations. The author used specially prepared sublimed carbon as electrodes. A hard cylindric carbon was made red-hot by current with the help of a transformer. From the sawed pencil thin plates were polished and the ends of the carbons covered with electrolytically deposited copper and put for 2 or 8 days into distilled water. After a few hours the carbons withstood 400-500°; only traces of water are lost at such a temperature. The ends of the carbons were boiled in sulphur at not higher than 120°, and polished with dry emery dust. Such electrodes are incomparably superior to metallic ones. Three such split carbon plates were placed with mica sheets interposed, the distance between the electrodes being from 0.5 to 1.0 mm. The lengthened carbon pile with the mica was put in a copper setting and compressed by means of a screw and spring. The plates were then placed in a porcelain jar, the whole being enveloped in asbestos cardboard and inserted in an asbestos cylinder, the space between the walls being filled in with sand. Observations were taken with an Ayrton galvanometer of sensitiveness 1.87×10^{-9} amp., current being taken at 100 volts from a battery. The results depend upon the treatment of the sulphur prior to the test—namely, whether the sulphur has been heated over 150° or to only 114° to 115°. The last temperature has no influence on the changes in conductivity. The sulphur was therefore divided into two groups: (1) sulphur which has not been under a higher temperature than 150°; (2) sulphur which has for a longer period been heated at a temperature of 150° to 250°. In the case of sulphur in crystals (puriss.) which was only heated to 117-120°, the conductivity rose with the temperature to near 150°, and afterwards decreased. The rapidity of change in temperature is also of influence. If the average rise of tempera-

ture is 5 deg. in 2 mins., the maximum of the curve is very inconstant and its temperature always above 150°. When heating is slow (especially at 120–160°) the maximum is reached at 140° and lower. Monkman had not noticed the maximum at 140–160°, but all the others have done so. The greatest difference between the author and Monkman is at 250–400°. At this point the resistance increases according to the author, whereas Monkman and Wigand found a decrease; this difference is probably due to the fact that these authors did not notice that the curve charge depends on the rapidity of the temperature change.

Group II.—In cases where sulphur had previously been heated to 150–160° its insulating properties disappear: thus at a low temperature (20–80°) sulphur is a good conductor.

The conductivity of sulphur which has been kept for some time at 170° and afterwards left at house temperature, does not remain the same. After a few days it increases, and this change lasts from 3 to 4 days, when it decreases, but it takes some time to return to its original state, and the length of time depends only on the temperatures which the sulphur was at before. Solid sulphur is therefore held to exist in three different states: Octahedral, prismatic, and amorphous. Octahedral sulphur at 170° becomes amorphous; also at a temperature of 40–50° sulphur, especially amorphous, changes into crystalline. Only octahedral is stable, and all the other kinds sooner or later get into this state. Thus we see that the electrical conductivity depends on the percentage of octahedral sulphur in the preparation.

Change in Electrical Conductivity of Sulphur Caused by Light.—Electrodes used in this research were made of Al, though they may be of lead, zinc, tin, etc. To determine the sensitiveness of sulphur to light the author used as a source of light a quartz tube lamp containing mercury, which took 80 volts, 8½ amps. The results obtained differed according to kind of sulphur used—crystalline or amorphous. In the case of the first, light did not exercise any effect upon the resistance. To increase the percentage of amorphous sulphur it was heated to 195–200° for 70 hours.

Galvanometer Deflection in mm.		Distance between Receptacle and Light Source in cm.
In the Dark.	Exposed to Light.	
20.0	39.5	10
20.0	85.0	15
20.0	81.5	20
19.8	28.8	25
19.8	27.0	30
19.5	25.0	35
19.5	24.0	40

I. P.

2004. *Current Induction in Vibrating Cylinders.* J. Kern. (Ann. d. Physik, 42. 2. pp. 480–484, Sept. 28, 1918. Extract from Inaug.-Dissertation, Zürich.)—A calculation of the damping effect caused by induced currents in a cylinder rotating about its axis (vertical) in a horizontal magnetic field. The motion is expressed by the equation for a damped simple harmonic motion, and the damping factor contains terms for the effects due to air and to the field. That due to the field is a function of the dimension ratio of the cylinder, and

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this function is expressed as a series, of which the first two terms are sufficient for calculations. The method is adapted for determining the variation of the conductivity of the cylinder with temperature.

G. E. A.

2005. *An Electrical Phenomenon.* A. A. Campbell Swinton. (Nature, 90, p. 821, Feb. 6, 1918.)—The author has noticed that, using a high-resistance (5000-ohm) telephone receiver, one terminal of which is held in the hand, when the other insulated terminal is applied to any metallic object of considerable size in his house a singing noise is heard corresponding in tone to the sound obtainable from the supply mains (continuous current). The sound is obtained even from stair-carpet rods about 8 ft. in length, especially near the top of the house, but ceases in all cases when the main switch of the supply is opened. Even with the switch open, however, the sound is heard if the telephone receiver be connected between the water pipe and a wire-netting aerial situated above the roof of the house.

L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

2006. *A Theory of Magnets.* S. B. McLaren. (Electrician, 72, p. 25, Oct. 10, 1918. Abstract of paper read before the British Assoc., 1918.)—After pointing out the difficulties in the way of modern electromagnetic theory, it is assumed that the electromagnetic field is defined by two vectors, E and H , i.e. the electrostatic and magnetic field intensities. The field is bounded by closed surfaces within which E and H do not exist. The space within these surfaces contains matter and outside them is ether. All formulæ are to be deduced from the principle of least action. The paper deals with the application of this principle and its results.

G. E. A.

2007. *Temperature Coefficient of Kew Magnet.* G. A. Shakespear. (Roy. Soc., Proc. Ser. A. 89, pp. 220-281, Aug. 27, 1918.)—An experimental examination of the dependence of magnetic moment of a Kew collimator magnet on temperature from which the author concludes as follows:—(1) For a steady rise of temperature, the relation between the moment m_t at a temperature t° above some standard temperature, O , may be approximately, represented by an equation of the form $m_t = m_0(1 - qt - q't^2)$, where q and q' are constants, and for a subsequent steady fall a similar equation holds, but with different constants. (2) If the rise and fall of temperature be not steady, the relation cannot be represented by any such simple equation. (3) There is always, even for a change of temperature of only a few degrees, a residual weakening of the magnet, which diminishes with time, if kept at constant temperature, until after about 24 hours the original value is very nearly regained. (4) It seems desirable that for accurate work the temperature of the magnet should never vary more than a few degrees. (5) For differences of field of the order $\pm H$ the temperature coefficient is not sensibly affected by the field.

E. H. B.

2008. *Conservation and Origin of Terrestrial Magnetism.* K. Birkeland. (Comptes Rendus, 157, pp. 275-277, July 28, 1918.)—The author having previously shown [see Abstract No. 1985 (1918)] how the motion of ions and electrons around the sun augments solar magnetism, now attempts to deduce the method by which the emission of solar electrons in space may give birth to terrestrial magnetism. He opines that a system of helio-kathodic rays exists

at present round the earth. There is, for example in the equatorial plane, an annulus where the radiation circulates so as to augment terrestrial magnetism, but since such rays by their direct magnetic action cannot account for more than 1/40th of the terrestrial magnetic force it is necessary to investigate whether this external radiation system may create induction currents during the earth's rotation, which may explain the diurnal variation of terrestrial magnetism and even the general phenomenon of terrestrial magnetism. It is impossible, however, that such a system should give rise by induction to electrical currents always circulating in the same sense round the equator, but the external helio-kathodic radiation may produce induced currents which change in direction during the earth's rotation. Under certain conditions, given in the paper, the terrestrial magnetism will always be increased whatever the direction of the earth currents, provided these are nowhere sufficiently strong to de-orientate existing magnetism. Electronic whirls may be set up, and wherever such an electronic system in dynamic equilibrium receives a new electron, the conclusion drawn is that the electron will be caused by magnetic forces to turn in the same plane and direction as the others. The author discusses the question of the conservation of terrestrial magnetism, and remarks that when the magnetisable crust is thickened by cooling, the magnetic elements in the new interior strata formed have received an orientation which, by reason of the enormous pressures involved, cannot be modified. He has commenced experiments to see whether the hypothesis may be verified on a laboratory scale. The author then explains the origin of terrestrial magnetism as due to the assembly of rays about the earth to form an equatorial annulus, and that the general magnetisation develops by successive reinforcement. The author promises later to apply his theory to the case of the rotation which the magnetic axis executes about the geographical pole.

H. H. Ho.

RADIOLOGY AND ELECTROPHYSIOLOGY.

2009. *Physiological (Retinal) Effect of an Alternating Magnetic Field.* H. L. Jones. (Roentgen Soc., Journ. 9. pp. 58-55, July, 1918.)—The behaviour of the retina to electric currents is peculiar. It is remarkably sensitive in one respect, and very insensitive in another. To stimulate it, the current requires to have a considerable duration, and a very long duration as compared with other irritable tissues, such as the motor nerves and sensory nerves. It is found that when condenser discharges are applied to the retina there is no response given with a capacity of 0.025 mfd. even with 100 volts although this produces a muscular contraction. With 0.05 mfd. a slight effect can be noticed, and if the duration of the discharge be doubled by inserting a resistance of 1000 ohms in series with the patient, a stronger visual effect is produced, although the insertion of the resistance reduces the energy of the discharge. With a resistance of 10,000 ohms and a condenser of 0.5 mfd. a visual effect is perceptible with 11 volts. The retina appears to be unable to respond to electrical stimuli which are less than 1/250 sec. in duration, and responds much better to waves which are very much slower, while motor nerves respond to impulses as short as 1/25000 sec. Reference is made to the work of S. P. Thompson, Peterson and Kennelly, Duchenne, Waller, etc.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2010. *New Element in the Atmosphere.* F. W. Aston. (Engineering, 96, p. 428, Sept. 26, 1918. Paper read before the British Assoc. at Birmingham.)—In his studies on the positive rays, J. J. Thomson obtained indication of the presence in the air of a body of atomic weight about 22 and giving a line next to neon, 20. The author has continued this work, and arrives at the conclusion that atmospheric neon is a mixture of two gases which are identical in all their properties with the exception of the atomic weight, which has the respective values, 19.9 and 22.1. By 8000 fractionations of the gas, or, better, by using the diffusion method in conjunction with a new quartz-disc density balance in which 0.5 c.cm. of the gas is weighed against oxygen, it is found that ordinary neon contains about 12.5 per cent. of the heavier gas, which does not appear to be a compound. The spectra of the two gases are apparently identical. T. H. P.

2011. *Electric Conductivity of Concentrated Aqueous Salt Solutions.* A. Sachanov. (Zeitschr. Electrochem. 19, pp. 588-589, Aug. 1, 1918.)—A preliminary communication. Having shown that certain anomalies occur in the molecular conductivity changes on dilution, and that these changes are influenced by the dielectric constant of the solvent when small, the author finds similar anomalies also on diluting aqueous solutions of typical binary compounds; but they appear already at very high concentrations, because the dielectric constant of water is very large. The conclusion is based upon experiments with AgNO_3 , LiCl , LiClO_4 , and on calculations deduced from the measurements of Kohlrausch and Sprung concerning NH_4NO_3 , KBr , KI . H. B.

2012. *Structure of Steel.* S. V. Biélynsky. (Rev. de la Soc. Russe de Métallurgie, pp. 896-920, 1912. Rev. de Métallurgie, 10, pp. 495-502, Sept., 1918. Abstract.)—A series of steels containing carbon percentages of 0.1, 0.4, 0.9, 1.4, 1.8, respectively, were examined as cast and chilled from the molten state, or cooled in the air, or cooled in the furnace. Sections of the ingots were etched in copper sulphate solution; in some cases the copper was subsequently washed away, and in others the steel was slightly rubbed by emery paper after removing the copper. The structures referred to are only such as appeared, after these preparations, to the naked eye or with a few diameters' magnification. The structure effects found are classified in considerable detail. The three main classes of structure, generally present more or less in superposition in all these cases are dendritic, network, and granular. The network structure is formed of secondary elements, ferrite and cementite, in a regular or elongated network, combined with a Widmanstätten structure. The granular structure is that most frequently studied; it is further pronounced to be similar to and identical with the fracture. Each of the three types is subdivided further, and the structures found are described in terms of these subdivisions. This will be best understood from the summary in the following two Tables, but the complete explanation of the subdivision symbols necessitates reference to the diagrams accompanying the original. Da is the dendritic structure. In the upper part of the ingot the axes of the

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first degree are longer than those of the second degree ; in the lower part they tend to be nearly equal. R is the network or cellular structure. Ra type has regular (equiaxed) meshes throughout but smaller at the top than at the bottom of the ingot. Rb has small cells in the lower part of the ingot, and elongated cells in the upper part. Rc has local agglomerations in the inter-axial surfaces of the dendrites ; the dendrites being distributed as in Da. G is the granular structure. Ga is irregular grains. Gb is irregular grains in the lower part and elongated irregular grains in the upper part of the ingot. Gc is regular grains (polyhedra). In 1DR the network pattern is independent of the dendrite pattern. In 2DR the network and dendritic patterns coincide. 8DR is practically the same thing as Rc, and is the limiting case.

TABLE I.

Carbon, per Cent.	Furnace-cooled.	Air-cooled.	Water-quenched.
0.1	Da, Ra, Ga, 1DR	Da, Rb, Gb, 2DR	(Da), (Rb), (Gb), 2DR
0.4	— — Gc, 1DR	— — Gc, 2DR	Da, Rc, Gc, 8DR
0.9	— — — 1DR	— — — (2DR)	— — — 8DR
1.4	— Rb — 2DR	— — — 2DR	— — — 8DR
1.8	— Rc — 8DR	— — — —	— — — —

Table II shows the sizes of the respective structures in mm.². Amongst other deductions the author finds that the sizes of the several structures are inversely proportional to the carbon-content and to the speed of cooling. The network structure become less pronounced as the dendritic structure becomes more pronounced. The dendritic structure becomes more pronounced (though smaller) as the carbon-content increases.

TABLE II.

Carbon, per Cent.	Dendritic Structure.		Network Structure.		Granular Structure.	
	Furnace-cooled.	Air-cooled.	Furnace-cooled.	Air-cooled.	Furnace-cooled.	Air-cooled.
0.1	650	18	800	3.5	27	8
0.4	200	180	150	8.8	0.5	0.8
0.9	—	100	4	—	0.4	0.2
1.4	180	90	8	2.2	0.25	0.085
1.8	15	—	1	—	0.2	—

F. R.

2013. *Air-liquid Contact Potential Difference*. G. W. Moffitt. (Phys. Rev. 2. Ser. 2. pp. 95-108, Aug., 1918.)—From a review of previous work it is concluded that no experimental determination that is entirely free from objection has as yet been made of any electrode potential, or of any liquid-liquid p.d., and that the question of the air-liquid contact p.d. has merely been raised. The purpose of the present investigation was to devise a simple and

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satisfactory method for the study of contact p.d.'s in those cases where liquids enter into consideration, and to seek out and eliminate if possible the unknown sources of erratic error which have caused such discrepancy in the experimental results of previous investigators. The whole aim of the work was not realised, but enough has been done to show that the problem of contact p.d.'s with liquids is more complex than has been thought. A form of the compensation method was used, and the general existence of a p.d. at the air-liquid contact has been definitely shown. The air-liquid contact p.d. may vary as much as 0.8 volt, depending on the condition of the liquid surface. Water and the aqueous solutions used are more positive to the air when the surface is clean than when it is contaminated. The value of the air-liquid contact p.d. (for the solutions studied) is approximately the same for aqueous solutions of different salts at normal concentration.

A. W.

2014. Electrometallurgy of Aluminium. I. The Ternary System Alumina-Fluorite-Cryolite. P. Pascal and A. Jouniaux. (Bull. Soc. Chim. 18. p. 489-449, 1918. Zeitschr. Elektrochem. 19. pp. 610-618, Aug. 15, 1918.)—The authors determine in nickel crucibles lined with graphite in Méker furnaces, the melting-points of cryolite 977° , fluorite 1861° , and alumina 2020° (estimated), and investigate the three binary systems and the ternary system. The ternary eutectic contains 59.8 per cent. of cryolite, 28 of fluorite, and 17.7 of alumina; it melts at 868° . The isothermals of the solidus are also determined.

H. B.

2015. Influence of the Addition to the Electrolyte of Free Sulphuric Acid and of its Neutral Salts upon the Kathodic Polarisation of the $\text{Cu} \mid \text{CuSO}_4$ Electrode. D. Reichinstein and A. Zieren. (Zeitschr. Elektrochem. 19. pp. 580-584, July 1, 1918.)—The cathodic polarisation of this electrode is qualitatively and quantitatively quite different in a neutral electrolyte and in an electrolyte containing a measurable H^+ concentration. The polarisation is much increased by the addition of both free H_2SO_4 and of a neutral sulphate (Cu , Zn , Mg , K , Na , NH_4). From the nature of the current density-concentration curve it is concluded that the addition in the first instance suppresses the Cu^{++} -concentration, and that secondly the slow reaction, on which the chemical polarisation depends, consists in the reduction of the Cu^{++} -ions by a cathodic reducing agent, which is primarily produced, and not in any gradual replenishing of Cu^{++} -ions from the undissociated CuSO_4 of the electrolyte.

H. B.

2016. Electro-deposition of Gold and Silver. F. C. Frary. (Amer. Electrochem. Soc. Trans. 28. pp. 25-97, 1918.)—A compilation of the various recipes which have been published for plating with gold and silver. In the electro-deposition of gold the following baths are dealt with:—Simple halide, cyanide, ferrocyanide, miscellaneous, containing little or no cyanide, baths for producing special colours. In the case of silver the baths dealt with are: simple salts, cyanide, baths for bright deposits, ferrocyanide, miscellaneous chloride baths, miscellaneous non-cyanide baths, baths for depositing silver alloys.

T. S. P.

2017. Electro-deposition of Cobalt and Nickel. O. P. Watts. (Amer. Electrochem. Soc., Trans. 28. pp. 99-152, 1918.)—A compilation of the various recipes which have been published for the electro-deposition of cobalt and

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nickel. The subjects dealt with are : Electroplating with cobalt ; deposition of an alloy of cobalt and nickel ; electro-chemical analysis of cobalt and separation from nickel ; electro-deposition of nickel ; purity and passivity of nickel anodes ; nickel-plating baths ; malleable nickel ; baths producing thick deposits ; agents for the production of smooth deposits ; nickel electrotypes ; the nickeling of zinc ; and the electrolytic estimation of nickel. T. S. P.

2018. *Electro-deposition of Lead.* F. C. Mathers. (Amer. Electrochem. Soc., Trans. 28. pp. 158-192, 1918.)—A review of the various methods which have been proposed for the electro-deposition of lead. The subjects dealt with are : Lead salts of the fluorine and perchloric acids ; lead salts of nitrogen acids ; lead salts of other inorganic acids ; lead salts of acetic, oxalic, and other organic acids ; alkaline electrolytes ; electrolytes giving lead peroxide ; non-aqueous electrolytes ; miscellaneous ; electro-plating and metal colouring. T. S. P.

2019. *Electro-deposition of Tin.* E. F. Kern. (Amer. Electrochem. Soc., Trans. 28. pp. 198-232, 1918. Chem. Engin. 17. No. 6. Chem. News, 108. pp. 57-59, Aug. 1, and pp. 68-70, Aug. 8, 1918.)—This paper is a compilation of data collected from the literature for the electro-deposition of tin. The subjects dealt with are : Electro-deposition by immersion ; electrolytic estimation of tin ; electro-deposition by separate current ; conditions necessary to obtain bright, dense, and adherent deposits ; electrolytic recovery of tin from tin-plate scrap and electrolytic treatment of tin ores ; detinning by combined chemical and electrolytic methods ; electrolytic refining of tin ; effect of organic addition-agents in tin electrolytes. T. S. P.

2020. *Electro-deposition of Copper.* C. W. Bennett. (Amer. Electrochem. Soc., Trans. 28. pp. 238-250, 1918.)—A compilation of the various recipes published for the electro-deposition of copper from acid and alkaline electrolytes and from electrolytes containing addition-agents. T. S. P.

2021. *Electro-deposition of Brass and Bronze.* C. W. Bennett. (Amer. Electrochem. Soc., Trans. 28. pp. 251-260, 1918.)—A compilation of the various recipes which have been published for the electro-deposition of brass and bronze. T. S. P.

2022. *High-tension Electrolysis: A Method of Measuring High-voltage Currents.* W. W. Strong. (Amer. Chem. Journ. 50. pp. 218-218, Oct., 1918.)—A transformer serves as a source of alternating voltage ranging between 5000 and 60,000 volts. A graduated vessel contains Pt electrodes and a dilute solution of sodium hydroxide as electrolyte, and is connected in series with a corona wire ; by the use of a rectifier the corona current may be made positive or negative. The results of the experiments showed that the gases given off at the electrodes were not in accordance with the volume ratio $2H_2 : O_2$, although the total quantity of gas evolved was of the order of magnitude to be expected from Faraday's laws. In many cases practically all the gas moved in the same direction as the electric current. If the electrolytic cell is placed on the grounded side of the corona discharge circuit, the electrolytic gas is given off in the same way as for low-voltage currents. T. S. P.

